A HISTORY OF NAVAL ARCHITECTURE, TO WHICH IS PREFIXED AN...

John Fincham

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THE ROYAL SOVEREIGN, BUILT IN 1637 (FROM A PAINTING BY VANDERVELDE.)

Plate 15

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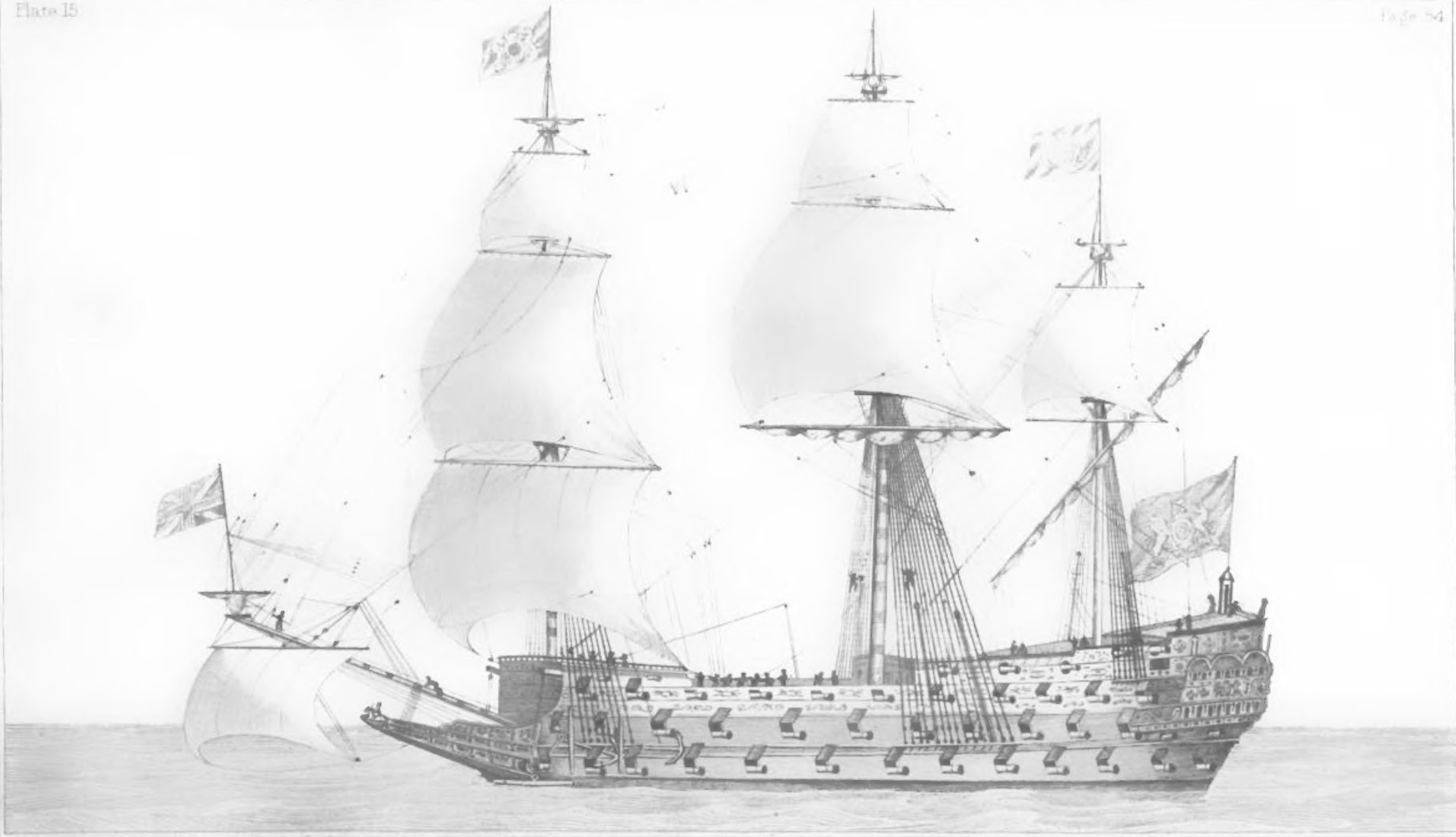

A HISTORY

OF

NAVAL ARCHITECTURE:

TO WHICH IS PREFIXED, AN

INTRODUCTORY DISSERTATION

ON THE APPLICATION OF MATHEMATICAL SCIENCE TO THE ART OF NAVAL CONSTRUCTION.

[WITH FIFTY-EIGHT ILLUSTRATIVE PLATES.]

By JOHN FINCHAM, Esq.,
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"AN OUTLINE OF SHIP-BUILDING;" "A TREATISE ON MASTING SHIPS,"
AND "DIRECTIONS FOR LAYING-OFF SHIPS."

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BRITISH MUSEUM

TO HIS ROYAL HIGHNESS

THE PRINCE ALBERT, K.G.,

ETC. ETC. ETC.

Sir:

In tendering to Your Royal Highness the humble expression of my deep and grateful sense of Your Royal condescension, in accepting the Dedication of the following History of Naval Architecture, I venture to hope that the character of the subject will procure for its imperfections an indulgent consideration.

I feel it impossible to doubt that both the national importance, as an art, and the high position as a science, of the subject treated in these pages will entitle it, in the estimation of Your Royal Highness, to a prominent place among those elevating studies and pursuits, the extending cultivation of which alike contributes to heighten the lustre of the reign of our gracious and beloved Queen, and to increase the greatness and prosperity of Her people.

That Your Royal Highness, in whom the arts and sciences have ever found a generous patron, and whose warm interest in all that concerns the welfare of Her Majesty's subjects at once commands their gratitude and esteem, may long continue to fulfil and adorn your exalted station among them, is the earnest desire and prayer of

Your Royal Highness' most humble,

Most dutiful and most grateful servant,

JOHN FINCHAM.

Her Majesty's Dockyard,
Portsmouth, *March,* 1851.

PREFACE.

The original intention of the Author, in preparing an account of the history and progress of Naval Architecture, was, that it should form an introduction to the third edition of his "Outline of Shipbuilding." It soon, however, became evident that the subject was too extensive for the limits assignable to an introductory essay; and whilst the materials which were available for such a History were sufficiently ample to call for their production in a separate form, it was felt, that the attempt was fully justified by the intimate connection of the theme with the naval and commercial greatness of the British empire. Narratives of the exploits of our naval armaments are, doubtless, more attractive and exciting to the national feelings than the details of their construction; yet, while on the one hand, the naval supremacy and commercial prosperity of Great Britain are legitimate objects of satisfaction and of hope, on the other, the history of the progress of the art of naval construction, from the production of the first unskilled design up to its present magnitude and importance, cannot fail to present, to all reflecting minds, a subject alike interesting and instructive.

The condition of Naval Architecture is ascertained in the services of ships and fleets: it has therefore been necessary to notice both the occasions of their employment, and their actual performances, as bearing on the progress which has been made in designing and building them. The relation of ships' performances to subsequent improvements in naval construction is, however, generally, not very marked;—still, most of the improvements in the British navy have been made only after experience had demonstrated their necessity. Hence, what a ship is able to do, as well as what is required of ships, whether in sailing, in evolutions, or in action, should be known to every naval architect who wishes to leave his profession in a better state than he found it in. These considerations have led to the introduction of the particulars of many actions in which British ships have been engaged with those of an enemy; the details are necessarily brief, and subservient to the main purpose of the narrative; in furtherance of which they will afford useful illustrations of the strength and condition of the naval force of the country, at the several periods at which they occurred.

In several of the European States, the science of Ship-building has long been an object of national interest. It has occupied a higher position as a subject of literature than in England; its profession has been more honourably esteemed, and its progress has testified the value of public patronage. Naval Architecture requires to be placed in the position, in this country, that Civil Architecture has always occupied; the want of such consideration and respect has given a depressed character to the art of ship-building in England, as well as to the cast of our literature connected with the subject. Spain, France, Russia, and Sweden have successively made Naval Architecture a national object, and each of those countries has produced one work or more of distinguished merit on ship-building; the names of Don George Juan, Bouguer, Daniel Bernoulli, Vial du Clairbois, Euler, Romme, and Chapman, claim this acknowledgment wherever their works are known; while England, though greater in maritime power, and far more deeply interested in the subject than either of those nations, has hitherto produced nothing comparable to the works of these authors.

It is not hereby contended, that literary distinction should be a principal aim of the naval architect; the enlargement and application of the theory, and the perfection of the art, are his immediate and legitimate objects. But the investigation and development of a theory so difficult, can be pursued only to the extent to which the study of the higher branches of mathématics and natural philosophy has been carried; and this, commensurate with the requirements of the present day, can hardly be expected, unless the profession of Naval Architecture be raised in rank: a step called for by the naval interests of England, and by the national honour identified with those interests. France has her *Génie Maritime*, whose members have both education and rank befitting their place in the service of the State. England, too, some years since, formed a school of Naval Architecture, but afterwards repented of having done so; and several of its members, who have since withdrawn from the Government service, have reaped the reward of their talents in other quarters. After the lapse of sixteen years, the system has been partially revived, on an altered plan; as the establishment is yet, however, in an early stage of its reconstruction, any opinion, as to its probable value to the service in its present form, would be premature.

It is freely admitted, that much of the improvement which is advocated in the foregoing remarks will depend on the qualifications and exertions of the naval architects themselves; but these being granted, if their reasonable claims be well enforced and sustained, they must eventually be conceded.

The difficulty of determining the laws of the resistance of fluids, and of the motions of ships in a sea, has led some persons to conclude that, so far as Naval Architecture depends on those laws, further progress is not to be expected therein: it might be so, if all whose province it is to investigate such subjects were of that opinion. But when we look at what has been accomplished in some of the physical sciences, in which questions of the greatest difficulty have presented themselves at the outset of an inquiry, and have had their exact solution at its close, it seems presumptuous to infer beforehand what may yet be the results of more patient investigation in this. The successful development of the laws of the planetary and lunar motions was long impeded by the difficulties which lay in the path of inquiry; but these, having been successively overcome, the laws have been clearly traced. Success so eminent as this should not only forbid despair, with regard to labours yet required to be undertaken for ascertaining the laws of the resistance of fluids, but it should both inspire confidence in entering upon such inquiries, and encourage a steady perseverance in their pursuit.

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⁂ The engravings in this volume are not given as finished and exact resemblances, but rather as illustrations of the distinctive character and variety in form and construction of the vessels represented.

ERRATA.

Page 12, last line, for *practical*, read *piratical*.
„ 12, line 12, for *Oberon*, read *Oleron*.
„ 12, „ 12, for *Larimer's*, read *Lorimer's*.
„ 21, „ 1, for *Danune*, read *Damme*.
„ 26, „ 2, for *to*, read *of*.
„ 30, „ 23, for *Montford*, read *Montfort*.
„ 35, „ 16, for *the other nations*, read *other people*.
„ 55, „ 41, for *Ramsborough*, read *Rainsborough*.
„ 56, „ 17, for *they*, read *it*.
„ 56, „ 17, for *Slingeby*, read *Slingsby*.
„ 65, „ 3, column 4, in the Table, for 6,545, read 16,545.
„ 67, „ 1, for 1000, read 1100.
„ 69, „ 35, for *of*, read *off*.
„ 72, „ 6, for *four-quarter pieces*, read *four quarter-pieces*.
„ 79, „ 41, for *Batchen*, read *Balchen*.
„ 82, „ 26, omit (*See Plate* 15).
„ 99, „ 35, for *in accounting*, read *of accounting*.
„ 101, „ 6, omit *the* before *Victory*.
„ 106, „ 3, from the bottom, for *the Royal Sovereign*, read *the armamen of the Royal Sovereign*.
„ 107, „ 26, for *are*, read *is*.
„ 109, „ 11, omit *the propriety of*.
„ 133, „ 31 to 33, read *The Franklin was named Canopus, the ancient name of Aboukir; and the Aquilon was called the Aboukir*, &c.
„ 138, „ 17, for *one of the two*, read *one out of two*.
„ 165, „ 6, from the bottom, omit *the* before *most*.
„ 166, „ 2, for *Charenk*, read *Charente*.
„ 181, „ 38, after 11 *feet* 6 *inches*, insert *in length*.
„ 194, „ 14, after *classes*, insert *which*.
„ 205, „ 39, for *Plate* 30, *fig*. 2, read *Plate* 31, *fig*. 1.
„ 206, „ 3, for *Plate* 31, read *Plate* 30.
„ 306, „ omit the foot-note.
„ 312, „ 6, for *his* read *this*.

INTRODUCTION

TO THE

HISTORY OF SHIP BUILDING;

SHOWING BRIEFLY THE APPLICATION OF MATHEMATICAL SCIENCE TO THIS ART.

It was not only during the earliest ages of the employment of ships, that the art of building them had to be carried on separately from the aid of science in their construction; but this state of things has marked almost the entire course of history. If we turn back to centuries that have passed away, we perceive that ships have been built much in accordance with the tastes of the ages respectively, determined ultimately, as mechanical skill was able to give a good or only an indifferent effect to the designs of constructors. But there were tastes proper to countries as well as to periods, marking a state of rudeness or of comparative refinement, long before any thing like a scientific basis was laid for so important an art. The development of art *never waited for this basis;* necessity impelled it onwards; and, along with many errors, it always associated some important truths; and, gathering on the side of truth, and rejecting on that of error, a long course of experience produced ships of a high order of excellence, and capable of fulfilling the objects of their respective periods, before any theory of naval construction existed, perhaps, fully as much to the satisfaction of those who built and of those who commanded them, as ships of the present age fulfil their destinations.

If we refer to the Elizabethan period of our own history, when the royal navy was not a century old, we perceive that the ships of that time were sufficient for the most intrepid courage of the British character;—and the circuit of the world was the sphere of its enterprize. Still, in the South of Europe, ships of nobler appearance were built; but, as the science or art of navigation existed at that time, there seems to have been a disparity between the magnitude of ships and the genius of seamanship.

During the seventeenth century, the fragments of knowledge were so much collected, that they seem to have formed a system superior to what may have been reasonably expected when it was wholly a subject of art.

When the *Royal Sovereign* was launched at Woolwich, it was found that her tonnage amounted to precisely the number of the date of the year in which that event took place. And this coincidence was regarded with a feeling at least bordering on superstition. The known defectiveness of the methods used for measuring the tonnage of ships at that time, as well as long afterwards, admits now of a question whether the coincidence was real or only imaginary. Allowing all that was alleged, it was nothing more than a curious accident.

M. Levêque, who translated Don Juan's celebrated work into French, in 1783, says, "towards the end of the last century, Europe had not a single theoretical work on navigation, except on pilotage. The construction of ships was abandoned to mere carpenters; and it was not considered that naval architecture was based upon a constant application of mechanics and geometry." This was not *wholly* true: for Mr. Phineas Pett, who was master of the Shipwrights' Company, and who was eminent as a constructor of ships for many years during the seventeenth century, was a graduate of the University of Cambridge, and so was not a "mere carpenter." We do not know that any one man gave a greater impulse to improvement in ship-building in England than he did. But after the time when he and his son, and sir Anthony Deane took the lead in the construction of ships for the British navy, there was a great declension of talent; and when ship-building was only an art, those who practised it were so bound by official establishments, that they followed their profession, perhaps, as "mere carpenters," according to the sense of the above quotation. And the construction of ships went on quite apart from any aid which it needed from science, and without claiming any direct attention from government to secure to it the advantages of that aid, until some years after the keen censure had been expressed against the defect of the system. It is not intended to question the proper application of the remark, without qualification, to the course of ship-building in the different countries on the continent of Europe, regarding which M. Levêque may have possessed the most accurate information.

If it is interesting to trace the progress of art in any of its useful branches,—to notice the features of transition in successive developments,—from the rudest to the most finished form in which its productions are exhibited, between the extreme points of any interval of time, it cannot be uninteresting to notice, in its connection, the germ and expansion of theory which may have aided its later improvements. We will, therefore, present a sketch of some of the contributions of science towards the construction of theories relating to naval architecture.

When Louis XIV. was filled with the ambition of realizing a naval supremacy, and when, under the able administration of Colbert, everything calculated to advance that object bore a value in France, science began to dawn upon the art of building ships. In 1673, Father Pardies published a treatise on statics ("Traité de Statique"), or the science of moving forces. In the investigation of an example, he determined the course which a ship sailing by a side wind ought to take. He considered that a ship's way was less than it would be if she divided the fluid with equal ease at all parts, in the ratio of radius to the sine of the angle which the sails form with the keel; and that the lateral way was also less than the direct way, in the compound ratio of radius to the cosine of the same angle, and of the lateral resistance to the direct resistance.

A brief notice of a treatise on naval architecture* that appeared very shortly afterwards, will show the state of knowledge on this subject at that time. It does not appear that there was a single principle, deduced from science, employed to determine any of the conditions stated in that work. The length of the keel was regarded as the first principle from which the dimensions and proportions of the other parts were to be determined. Taking this as a basis, the work contains the dimensions of ships of the four rates of the line, and of four classes of frigates, arranged in the Table on the next page.

It is clear that such treatises could be of little use beyond that of making the best practices general: they could not go beyond the point which practice had already reached. Improvement could, then, hardly be expected from them,—as they could not anticipate. Being, also, necessarily subject to imperfection, the growth of experience would soon make them of little help even in practice: they would serve, however, as indexes from which may be inferred the progress within any two periods. The treatise of M. Dassié shows what was the state of knowledge in France at a period long after the south of Europe had been occupying a distinguished eminence in naval architecture, and when French ships were looked at as models for English builders to imitate. For, although the French navy was yet in its infancy, the care and energy of Colbert had been assiduously applied in developing its powers; and the results of these were its rapidly advancing improvements, and its magnified importance. But it is evident that the attention of constructors had been directed to conditions, already tried, of building ships, rather than to the principles of construction.

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* L'Architecture Navale, contenant la maniere de construire les Navires, Galères et Chaloupes, et la definition de plusieurs autres espèces de Vaisseaux, par le Sieur Dassié, C.R.; Paris, 1677.

TABLE SHOWING THE PROPORTIONS OBSERVED IN THE CONSTRUCTION OF SHIPS.

RATE.	Length of the Keel.		Height of the Stem.		Rake of the Stem.		Height of the Stern-post.		Rake of the Stern-post.		Length from the Stem to the Stern-post.		Breadth to the outside of the Timbers.		Depth in Hold.		Breadth of the Flat of Floor.		Height of the Midship Frame.		Tumble-home of the Top-sides.		Height between the Gun and the Main Decks.		Height between the Main and the Quarter Decks.		Height between the Quarter-deck and the Poop.		Breadth of the Wing Transom.		Height of the Taffrail.		Tumble-home of side Stern-timbers.		Height of midship main Breadth.		Load-draught of Water.		Burthen in Tons.	Number of Guns.	Projection of the Knee of the Head.	
	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	in.	ft.	ins.	ft	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	ins.	ft.	in.	ft.	in.	ft.	in.	ft.	ins.	ft.	ins	ft.	in.	ft.	ins.	ft.	ins.	No.	No.	ft.	ins.
1st Rate........	147	6	36	10	29	6	33	1	7	4	184	4	48	4	22	0	23	0	40	0	12	0	7	9	7	2	6	7	33	1	61	5	8	2	20	5	23	10	1920	114	20	5
	142	0	35	6	28	5	31	10	7	1	177	6	46	7	21	3	22	1	38	4	10	10	7	7	7	1	6	6	31	11	59	2	7	10	19	8	23	0	1711	100	19	8
2nd Rate	136	7	34	2	27	4	30	8	6	10	170	9	44	9	20	4	21	3	36	11	10	4	7	4	7	0	6	4	30	8	55	9	7	7	18	11	22	5	1530	90	18	10
	131	1	32	9	26	3	29	6	6	7	163	11	42	10	19	6	20	5	35	6	10	8	7	3	6	11	6	3	29	6	54	7	7	3	18	2	21	2	1357	80	18	2
3rd Rate	125	8	31	5	25	2	28	4	6	4	157	2	41	3	18	8	19	5	33	11	10	3	7	1	6	10	6	2	28	2	52	4	6	11	17	3	20	2	1175	72	17	4
	120	2	30	1	24	0	27	3	6	1	150	3	39	3	17	5	18	7	31	8	9	9	7	0	6	9	6	1	26	2	50	1	6	8	16	7	19	4	1043	66	16	8
4th Rate........	114	9	28	9	22	11	26	0	5	8	143	4	37	6	17	1	17	9	31	0	9	3	6	11	6	8	6	0	25	9	47	9	6	3	15	10	18	5	892	60	15	10
	109	3	27	4	21	10	24	9	5	5	136	6	35	9	16	3	17	0	29	7	8	10	6	9	6	6	5	11	24	6	45	6	6	0	15	1	18	2	769	54	15	1
Frigate, 1st cls.	103	9	26	0	20	9	23	5	5	1	129	7	32	10	15	4	14	8	25	11	8	1	6	7	6	3	5	10	23	3	43	3	5	9	14	4	17	0	642	50	14	4
	98	4	24	9	19	8	22	2	4	10	122	10	32	2	14	7	14	0	24	7	7	10	6	6	6	1	5	9	22	1	40	11	5	6	13	7	16	2	560	46	13	7
Frigate, 2d cls.	93	0	23	6	18	7	20	10	4	7	116	2	30	5	13	10	13	2	23	2	7	7	6	3	5	11	5	5	20	10	38	8	5	1	12	10	15	2	469	42	12	9
	87	5	21	10	17	6	19	8	4	4	109	3	28	7	13	1	12	5	21	10	7	0	6	1	5	9	5	2	19	8	35	3	4	10	12	1	14	3	405	38	12	1
Frigate, 3d cls.	81	11	20	5	16	5	18	6	4	0	102	4	26	9	12	9	11	7	20	8	6	8	5	11	5	8	4	10	18	4	31	10	4	7	11	4	13	3	333	34	11	4
	76	5	19	1	15	4	17	3	3	9	95	6	25	0	11	11	10	10	19	1	6	1	5	9	5	6	—		17	2	29	8	4	2	10	6	12	5	271	28	10	5
Frigate, small	71	0	17	9	14	3	16	0	3	6	88	9	23	3	11	1	10	1	17	9	5	9	5	5	5	5	—		15	11	27	7	3	10	9	10	11	9	202	18	9	9
	65	6	16	5	13	2	14	9	3	3	81	11	21	5	10	2	9	4	16	4	5	3	5	2	5	5	—		14	8	25	6	3	7	9	1	10	7	168	14	9	1

In this treatise the proportions are stated in order, having the keel as a basis; and practical instruction is given for drawing the plan of the body, and forming the transverse sections. And the details of the quantity and expense of the timber and planking required in building a second-rate ship are given, with other information, highly useful then, without doubt; but certainly of limited value in point of time.

One can hardly fail of perceiving the immense superiority of well-constructed theory; inasmuch as, if the principles are true, they anticipate all coming time, and are applicable in all conceivable diversities of practice; while they supply the means of acting with decision, on sure grounds, even in the most trying emergencies. Theory, has, however, all along had two grand obstacles to encounter. The extreme difficulty of applying abstract principles to so complicated a machine, with the conditions of its proper element so little understood, has been the chief. And a common aversion in practical ship-builders to have recourse to theory, has always been *one* of the difficulties and discouragements of science;—probably following as a consequence of that which precedes.

The importance of placing the operations of naval architecture on a less uncertain basis, led to a series of conferences on the subject, at Paris, in 1681. A number of eminent men attended these conferences, amongst whom was the chevalier Renaud. They did not, however, investigate the subject with reference to any fixed principles of science; but confined their attention for the most part to the external form of ships. These were considered as geometrical bodies, whose figure was very nearly known, and the object of their inquiry was, greater ease or elegance in forming the outline; not regarding them at all as natural and heterogeneous bodies, and, as such, requiring the application of mixed rather than of pure mathematics. M. Renaud formed the curves of ships by means of the conic section.* On this subject, M. Bouguer remarks, that these curved lines were not preferred because they were discovered to possess any peculiar advantages which rendered them more suited to this use; they were employed because they were better known, or more easy to describe: they presented themselves first.

In 1689, the chevalier Renaud published a work on the theory of the management of ships, which was at first in much esteem, as it was said to contain the principles of a new science. This author agreed in some respects with father Pardies; and also, he fell into some of his errors. Further, he admitted, in common with most other scientific men, that the resistances were as the squares of the velocities of the fluids, and as the square of the sine of the angle of incidence of the water upon the surface which it strikes. It was not long before the fallacy of some of his arguments was detected by Huygens, and they were exposed by him in the "Bibliothèque universelle et historique," in 1693. He showed that, according to the principles of M. Renaud, a ship ought to have a much greater velocity than he had assigned to her, and also, that he had been mistaken in fixing the angle to which the sails should be trimmed in sailing close-hauled: almost the entire theory was, therefore, discredited. The chevalier Renaud was not convinced of the unsoundness of his principles, and published his answer in the "Journal des Savants," 1695, defending his opinions by reference to the principle of the decomposition of forces. M. Huygens replied, but, it seems, inconclusively; and he died almost immediately afterwards. The chevalier Renaud gained confidence from the unsatisfactory answers of Huygens; but the question was occupying the attention of others; and in July 1696, an article appeared in the "Actes de Leipsic," written by James Bernoulli, professor of mathematics at Groningen, admitting the opinion of Huygens, with some exception. He did not admit, with him and the others who had written on this subject, that the velocity of the wind was infinite in relation to that of the ship, a change in the principles which necessarily altered some of the results he was led to. M. Renaud then published a "Mémoire où est démontré un "principe de la mécanique des liqueurs, dont on s'est servi dans la Théorie "de la Manœuvre des Vaisseaux, et qui a été contesté par M. Huygens." He is, however, charged with confining himself to a defence of his proposition on the decomposition of motion, and of failing in his purpose to disprove the criticisms of M. Huygens. John Bernoulli, professor of mathematics at Basle, on first taking a part in this controversy, was in favour of M. Renaud; but, on maturer consideration, he embraced the opinions of Huygens. In 1714, he, therefore, published an "Essai d' une Nouvelle Théorie de la Manœuvre des Vaisseaux." His more profound mathematical learning enabled him to extend his investigations beyond those of the authors who had preceded him. He agreed with the velocities which M. Huygens had found for ships; but, as he did not limit the velocity of the wind, he could not obtain results with so much exactness: he made some addition to the theory, by tracing the curve which determines the velocities. He also attended to the obliquity with which the wind strikes the sails, which had been omitted by his brother;—investigating first the most advantageous angle of the sails with the wind, their angle with the keel being assumed, and then their most advantageous angle with the keel, their angle with the wind being assumed;—and proceeded to treat of the union of the two angles so found, to be most advantageous to the ship in sailing close-hauled. But, in all his reasoning on this subject, he proceeded on two suppositions,—that the velocity of the wind is infinite, and the lee-way zero,—both of which are erroneous. His speculations indicated the necessity of investigating the resistance opposed by the water to ships in their passage through it. He, therefore, made allowance for the suitableness of the forms of ships for dividing the water: the form having been regarded as a rectangle, in the reasonings of the three preceding authors. But the investigations in which he engaged, were deficient of practical utility, not being associated with knowledge drawn from experience.

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* "Histoire de l'Académie Royale, par M. du Hamel."

In order not to violate the necessary connection of these remarks, an author of great celebrity on naval tactics, who wrote also on naval construction, has been passed by, as he took a position quite independent of the controversy which was then engaging the attention of scientific men. We return, therefore, to the notice.

In 1697 a learned jesuit, Paul Hoste, professor of mathematics in the royal seminary of Toulon, published a work on the theory of naval architecture.* He says, "It cannot be denied that the art of constructing ships, which is so necessary to the state, is the least perfect of all the arts. The best constructors build the two principal parts of the ship, viz., the bow and the stern, almost entirely by the eye; whence it happens that the same constructor, building at the same time two ships after the same model, most frequently makes them so unequal, that they have quite opposite qualities.

"Chance has so much to do with construction, that the ships which are built with the greater care are commonly the worst; and those which are built carelessly, are sometimes the best. Thus the largest ships are often the most defective; and more good ships are seen amongst the merchantmen than in the royal navy.

"Also the treatises on naval architecture which have hitherto appeared, have touched only upon the surface of the construction of ships. The writers have satisfied themselves with giving the name, form, connection, and use of the various parts of a ship, with some general proportions, which chance or caprice had introduced amongst constructors. But who does not see that all this may teach to build ships either good or bad? and not to make them good with the greatest certainty and facility, and with the least possible expense, as the perfection of the art requires.

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* "Théorie de la Construction des Vaisseaux, qui contient plusieurs traitez de Mathématique sur des matières nouvelles et curieuses.

"It is true that for some years past, the French ship-builders have laboured at improving their art. Some have begun to make plans, in which they have determined all the frames or models of the bow and stern; but as they have not the necessary principles, they labour with little certainty. Their ships are not better than those which were built without the knowledge of either reading or writing: they do not sail better—often they do not carry sail so well—they rather hog—they are less durable; in a word, the constructors of the present day agree with the ancients, that *it is not yet known what the sea requires.*

"I am not ignorant that very able persons have flattered themselves that they have found by practice in frequent trials, what they have not found in theory. But I think they will be troubled at succeeding; a ship is too complex a machine, and too many things are required to concur to make her perfect, to be able to meet perfection by chance." *

We learn from this author that there was a general deficiency in the stability of French ships, although constructors were carefully intent on giving them enough of this property. But as they rarely succeeded, almost all the ships in the French navy required doubling before they would carry sufficient sail for the purposes of navigation. "It seems," he says, "that it should be easy to constructors to make their ships carry sail, in giving them, upon the stocks, the form which they have after having been doubled; but as this form would make them worse sailers, and as other ships carry sail without this form, constructors have not been able to decide on using this means." † The increase of heavy ballast in the hold had been tried, and found not to meet the requirement. He undertook, therefore, to investigate the subject on geometrical principles, to determine wherein consists the power of a ship to carry sail, and what the form of the ship contributes thereto.

All the reasoning on the properties and characters of ships is preceded by a long series of propositions, geometrically demonstrated,—on the parts of mechanics involved in the question,—from the very elementary, to abstruse and difficult problems. The relative difficulties with which bodies divide a fluid in passing through it, are discussed at length; and both principles and conditions are stated and investigated. It is, for instance, stated, that "the difficulty which a moving body finds in dividing the medium, increases in the same ratio as the velocity:" * that "the circle finds more difficulty in dividing the medium by its flat than all other polygons equal; and the triangle finds less. In like manner, of all equal triangles, that which is equilateral finds more difficulty in dividing the medium by its flat, and that which is more remote from the equilateral finds less." † This principle is of course applied to solids.‡ But "the pyramid has no more difficulty in dividing the medium by its base than by its vertex." §

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* "Théorie de la Construction des Vaisseaux," Preface.

† *Ibid.*, Liv. i., chap. ii., p. 46.

The position of the centre of gravity is considered in relation to the power to carry sail. And after investigating the forces of weights placed unequally away from the vertical line, in which the centres of gravity of the ship and of her displacement are found, whether within or without the ship, we find this: "If the centre of gravity of the ship is known, the force which she has to carry sail is easily known, which is no other thing than the product of the weight of the ship by the distance between these centres." ||

The next subject examined is the manner in which forces act upon the masts to incline a ship. Different positions are assigned to the forces, the relative powers of which are investigated geometrically; and as well the force which depresses the ship in the water, as that which causes a lateral inclination. But when a power, acting on the mast in a horizontal direction, inclines a ship, it does not plunge her more deeply into the water. The sections of the ship are supposed to be segments of circles; and the centre of gravity of the section is supposed to be the centre from which the segment is drawn. The same principles are applied to ships terminated by plane surfaces; and it is thereby proved that the rolling motion must be uneasy, in proportion as the form of the sides at the water-line is flaring or tumbling home, as in that motion continued, the ship experiences constant alterations of rising and sinking in the water, in relation to her centre of gravity; this centre not being that about which the motions are performed.¶

The manner in which the doubling of ships increases their stability is considered;** but as our author always states the measure of stability to be the product of the weight of the ship and the distance between the centres of gravity of the ship and of her displacement, the beneficial effect ascribed to doubling is said to be only as it increases that multiple, either by elevating the centre of gravity of the ship, or by increasing her weight; or by realizing both these effects conjointly.

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* *Ibid.*, Prop. 5.

† Prop. 17, Cor.

‡ Prop. 67, Cor.

§ Prop. 66, Cor.

|| Prop. 127, Cor.

¶ Props. 150, 151.

** Props. 155-6-7.

Before stating the conditions which affect the character of pitching and 'scending, the simplest state of these motions is considered: when the ship is at anchor in a smooth sea, a wave then coming strikes her bow and elevates this extremity; in this case, the movement is accelerated until it has reached its limit. The summit of the wave, then passing along the sides of the ship to her stern, elevates that extremity; and the corresponding depression of the water forward, leaves the bow to fall with an accelerated velocity also; and so on successively with every following wave.*

When a ship is under sail, and meets the wave, the force of the shock and the velocity of the ascending movement are greater; and unless a second wave passes underneath to sustain the bow, this extremity falls back more heavily, and sinks more deeply into the water than if the ship were at anchor. On the contrary, if the ship go in the same direction as the waves, and at the same velocity, she will not pitch; and if her velocity be a little greater than theirs, she will pitch very easily.†

In connection with this subject, stowage is noticed, but it appears not fully enough. "All the skill of stowage consists in placing the centre of gravity of the ship as far aft as possible:" ‡ for "if the centre of gravity of a ship is more forward, she will, on that account, pitch the more;" and if the draught of water forward is greater than that abaft, she will plunge more into the wave, be lifted by it with greater force, and fall back more heavily than if it were less.§

A ship, being supposed of given form, and having a definite movement, on being laden more heavily, will not rise less above the wave; but in descending, she will plunge more into it. But, although "a ship which is more laden ought commonly to pitch more," yet he says "*commonly*, because the figure of the ship may make her pitch less when she is the more laden." ||

The conditions of form affecting the pitching of a ship are, the sharpness of the bow below the water-line, and the curve described by the stem. For, other conditions of the ship remaining the same, if she is made leaner forward, she will still be raised by the wave with the same force,¶ and even with more accelerated motion;** but having a smaller volume of water to displace in plunging, she will penetrate the wave with more ease, and, hence, plunge more deeply into it.†† Therefore, "ships which are very sharp forward, commonly pitch much." ‡‡

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* Théorie de la Construction des Vaisseaux, Liv. i., Chap. iii., Props. 163, 164.

† *Ibid*, Liv. i., Chap. iii., Props. 165, 170.

‡ *Ibid.*, Prop. 174, Cor.

§ *Ibid.*, Sec. ii.

|| Props. 175, 176, and Cor.

¶ Prop. 183.

** Prop. 184.

†† Props. 182, Dem. 185.

‡‡ Prop. 185, Cor.

The stem of a ship is supposed to be an arc of a circle: the relative height of its centre is then the condition from which is deduced the power which the shock of the wave has to elevate the bow. For the radius of such circle, meeting at the bow of the ship a horizontal line, at the same height that the wave strikes it, and forming there an angle; the motion of the wave is to that which it impresses on the bow of the ship to raise it, as radius is to the sine of such angle. But the ratio of radius to this sine is great in proportion as the centre of the circle is near to the water-line.* Therefore, "the more the centre of the figure which forms the bow of the ship is elevated, the more force the wave has to raise it, and, consequently, the less it enters into the wave, the less it plunges in falling, the less she pitches.†

The same consequence is enunciated in respect of placing the centre of gravity longitudinally in building a ship, as by her stowage: that the bow of a ship being farther from the centre of gravity, she will rise with less acceleration, and plunge and pitch less. ‡

The shock of the wave, acting as well in diminishing the velocity, as in producing the motion of pitching, we have this force resolved into its two parts. We have seen the ratio of this force in raising the bow; the other ratio is as radius to the sine of the angle of incidence of the wave against the ship; and it is this which diminishes the velocity.§ *This* ratio is greater, as the centre of the circle of which the stem is a segment, is high; hence, "the wave which strikes the ship retards her less when the figure of her bow has a more elevated centre."||

The rolling of ships is noticed most superficially. The conditions of rolling are, for the most part, identified with the relative positions of the centres of gravity of the ship and of her displacement. "All the rest remaining equal, the rolling is heavier when the centre of gravity of the displacement is lower:—the same if the ship is heavier, all the rest remaining equal, the rolling is harder. The rolling is less hard when the point about which the ship rolls is higher, all the rest remaining the same." ¶

We have rested the longer on the notice of this work, as it is the first in which we find any attempt at bringing the construction of ships under the ruling power of mathematical science. Unable to acknowledge an accuracy in many propositions in which the author professes to demonstrate some of the most important principles in the construction of ships, it cannot,

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* Prop. 189.

† Prop. 189, Cor.

‡ Prop. 190, and Cor.

§ Prop. 193.

|| *Ibid.*, Cor.

¶ Props. 206-7-8.

nevertheless, be uninteresting to see how far he applies the principles and reasonings of geometry. The work supplies a proof of the extent to which science could be applied at that time, in constructing a theory of naval architecture. No disappointment is felt at witnessing the small measure of success that rewarded the effort. Apart from the deficiencies of the theory, and the erroneous propositions which it includes, it may, perhaps, be fairly supposed that it appeared before the time when practical ship-builders were at all prepared to countenance such a work, by adopting purely mathematical principles as the basis of their designs. Nor is this all: the men who ruled the interests of the French marine, seem not to have favoured science; for, whilst the council which sat at Paris, in 1681, may have had no abler work to ground their discussions and determine the future plan of constructions on, than that of the Sieur Dassié, we see that the government of France continued to build ships on the plan determined by that council, for half a century after Paul Hoste's theory was published.

A period of practical enterprize in navigation had long ago set in, and the plan of European warfare was increasingly making the results of national conflict dependent on the respective naval powers. These two facts combined to forbid a return to indifference on whatever related to this power in Europe: but whilst motives to the cultivation of naval architecture were presented on every side, there appears to have been a general misapprehension of the means by which improvement should be carried on. Paul Hoste's treatise was dedicated to the king; but it appears to have failed of producing any effect in modifying the construction of ships. This failure can hardly be attributed to the unsoundness of his views on some of the most important conditions of the art; for it would be a very free supposition, that whilst science was but just *beginning* to be applied to the subject, it could detect the fallacies into which he had fallen.

Naval construction, and the theory of navigation, continued, however, to engage some attention; the mathematicians of the Continent giving their thoughts thereon, in the course of a lengthened controversy that was carried on in their literary journals and otherwise.

This controversy appears to have arisen, indirectly, out of a previous work written by Paul Hoste, and published in 1692. Some of the views enunciated in that work differed from those laid down in his work on the construction of ships; perhaps they were sounder, as between the periods of writing the two, he changed his opinion on the resistances of fluids. Our author, as well as the chevalier Renaud, drew the principles embodied in his first work from father Pardies, who had written a discourse on moving forces, and on the motions of ships; but who has not the reputation of rigid accuracy in his reasonings. Although P. Hoste was deeply interested, yet he took no part in this controversy, leaving it to the hands of some of the most celebrated mathematicians of the continent. It was begun by M. Huygens, and, extending over a period of nearly half a century, it was concluded by M. Bernoulli, in the publication of an essay on a new theory of seamanship. The resistance of fluids was investigated and discussed; but with too much dependence on abstract principles, apart from accurate experiment. A great difference of opinions, therefore, appeared; and the experience of later times, both in France and in England, has proved that neither party was right; for, although no efforts have yet succeeded in establishing a definite ratio of resistance with the velocity of the body passing through the fluid, yet it has been clearly shown that the resistance is neither proportional to the simple velocity, and to the sine of the angle of incidence, according to P. Hoste, nor to the squares of those quantities, according to other mathematicians.

All that was written in this controversy was too incomplete, and came out in too desultory a manner to be of much benefit in naval architecture. Knowledge on this subject was disjointed, being found rather in fragments than in association. Thus, apart from the established conditions which, by *authority*, ruled the construction of ships, there was scarcely anything to guide besides the results of experience. Nothing was done effectually to point out to ship-builders the necessary relations of collateral facts; and in this state of things, the simple observance of these facts was of but little use. Even the imperfect knowledge that was possessed on this subject had too limited a circulation amongst those who practised the art. Practical constructors grew jealous of theorists; and truth was rather suppressed than declared by those with whom it was lodged. The principal dimensions of ships were stated; but the necessary details of forming the body were given only in a manuscript book, written by M. de Pulmi, which, however, was copied, and had some limited circulation in that state. To a great extent their personal knowledge might be included within limits that it was not creditable to tell; and that circumstance might be a motive why they were so little communicative. On the testimony of M. Bouguer, we know that the knowledge of merely practical ship-builders was grossly defective. He says, "It always happens that they think differently from each other; and yet each alleges, with equal confidence in his favour, his own practice, or a tedious list of ships which he has already constructed. As it is impossible to reconcile them, because they have no means of doing it,—neither common principle of agreement from which they can set out, nor rule, nor even index to discern the truth by, or to bring them acquainted with it, they are reduced to a continual repetition of the same assertions in the place of proofs." *

This state of naval architecture showed the necessity of treating the subject in a fuller and more intelligent manner than any author had yet done. The extreme complexity of the subject, and the importance of avoiding the intricacy of symbolical reasoning, were fully perceived by the author of the elaborate treatise just quoted. His work has, therefore, but little of algebraic formulæ; the investigation of principles being conducted more by the aid of geometry than by mixed mathematics. At the same time, he distinctly acknowledges the insufficiency of abstract reasoning to reach the end he had in view, whilst he had proof enough of the inadequacy of knowledge derived simply from practical sources. "Experience would be the best means of perfecting naval architecture, if the thing were possible; but it is plain enough that practice is insufficient in many cases. It is certain, that if this alone is capable of rendering some parts perfect, it has need, in an infinity of others, to be aided by the light of theory." †

With so distinct and full a perception of the value of practical knowledge, in connection with what theory might enunciate, he describes the different sorts of ships to which it was necessary to give attention, and enters into a detail of the parts composing them. It is not necessary to follow these details, either of the parts of ships, or of the way in which the relative strength of any part was shown to be sufficient or otherwise; nor is it within the compass of this brief notice to say anything of the several practical methods of forming the midship and some other sections, any more than of the curves determining the outline of the body. It was, however, in giving to the body such a figure as would best suit the conditions of a ship that the great difficulty was felt. He says, "But if the ordinary maxims must be found imperfect, it is principally in the figure itself which is given to the body of ships; for it was impossible to discover, by practice alone, and by trials, how often soever repeated, the particulars of an entire curved surface, which is an assemblage of an infinity of curved lines and of points. It must not, then, be doubted that it is here where construction needs to be reformed. It may happen, in particular conditions, that we cannot rigorously follow the precepts of theory; but it is at least always advantageous to know them, in order to have in view the point of perfection, at the same time that we cannot reach it, and are obliged to stop short of it." ‡

The consideration of the character of the curved surface forming the

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* Traité du Navire, Preface, p. xviii.

† *Ibid.*, Liv. i. Sec. i. Chap. x.

‡ *Ibid.*, Liv. i., Sec. i., Chap. x.

bow of a ship, should necessarily include some inquiry into that form which offers the least resistance to direct motion. This subject is therefore discussed;* and the properties of the conoidal curve are treated of at some length, with the different forms of bases, which affect more or less the value of the curve in receiving the impulse of the water with the less direct resistance. The difference of form suited best to oblique sailing, is also stated in connection with the other.

But, as it does not follow that the curve of least resistance is that best suited to fulfil the conditions of a ship's bow, the advantages of different forms are brought under review and investigation. And, as the form which would realize the greatest speed in running, would not be the best for sailing by the wind, the relative characters of different forms, in respect of the resistance they would oppose to the vertical as well as to the horizontal pressure of the water, are considered.

It is not intended to notice generally the considerations which this complicated subject includes: a few must be alluded to. After some observations on the inertia of the whole mass of a ship in the water, the following statements are made: "Another object must be attended to, if ships were intended to sail only before the wind. It would be necessary to make the relative vertical pressure of the water on the bow as great as possible in relation to the pressure which is borne in the line of the axis. The bow being then pushed upwards with the greatest force, or what amounts to the same, the direction of the impulse of the water making a great angle with the horizon, the *point velique* would be more elevated; the ship would be able to carry more sail, and higher masts in a direct course, which would infallibly make the speed greater, since the resistance of the water at the same time would be as small as possible, regard being had to the great impulse of the wind. But it appears more certain to regulate the dimensions of the sails by what is required in oblique courses, in which too much height of masts would expose them to greater dangers. In effect, if greater dimensions are given to the masts, in order to have their advantage in a direct course, the ship would be liable to be lost whenever it should be necessary to pass suddenly to a very oblique course, before time should be had to take in the sails. Further, it must be remarked, that the property which the bow would have of being pushed upwards vertically with greater force, would prejudice that which it ought to have, of being exposed but little to the impulse in the direction of its axis. These two advantages, very far from being united, are on the contrary really incompatible, in almost all figures, if we except some,—as the bow, which is terminated by a single rectangular plane, inclining forwards.

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* *Ibid.*, Liv. iii., Sec. v., Chap. iv.

"Thus, we ought to propose to ourselves, in the present discussion, to diminish the resistance which the bow experiences in dividing the water, only to the extent that it can be done without too much injuring the magnitude of the masts; the ship will then sail faster with a fair wind; and this advantage will be possessed without running a risk. We ought not to render the resistance an absolute *minimum*, as heretofore, but to render it the least that we can, regard being had to the moment of the weight of the ship in relation to the métacentre; because the quantity of sails that the ship can carry depends on the greatness of this moment." *

Whilst the conoidal curve forms the most advantageous limit for a ship's bow, our author says, "In proportion as we suppose that the total moment of the weight of the ship diminishes, we must make the bow full, forsaking, consequently, the figure of least resistance; and the other limit, that of the greatest fulness, is found when we take away all the after body, or when the moment of the weight of the ship is reduced to be the moment of only the weight of the fore body. But in this last case, the same as in all the others which are intermediate, the most advantageous figure then becomes more and more conformable to that of the least resistance, according as it approaches from its extremity to its summit; and that because the moment of the remaining part diminishing always in relation to the total moment, it is more right to consider this last moment as infinite.

"Further, this relation which there is between the two figures of the bow *of the least resistance* and of the bow *of the greatest velocity*, these two figures become absolutely the same, whenever the horizontal section of the body at the water-line is given, or is regarded as invariable. We are obliged to suppose here that the centre of gravity of the ship is precisely in the same point as the centre of gravity of her displacement; since we do not know of what substance the lading or ballast must be formed. Besides, it is sufficient that the weight be distributed in a similar manner in the different figures that are actually compared, that this supposition may never lead to error. But as soon as the horizontal section of the body, at the water-line, is invariable, without the various figures of the bow making any difference in it, the power of the ship to carry sail is constant, it is equal or proportional to the product of the weight p by the quantity $\frac{\frac{2}{3}\int y^3 dx}{p}$ by which the centre of gravity is below the métacentre; and this product or this moment is equal to $\frac{2}{3}\int y^3 dx$. Thus the alteration which would be made to the figure of the least resistance, would be not only useless, it would be without any reason." *

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* Traité du Navire, Liv. iii , Sec. v., Chap. v.

Although M. Bouguer conducted his investigations and reasoning with reference to the height of the métacentre above the centre of gravity of a ship, yet it does not seem that he was satisfied of the sufficiency of that method of estimating its stability. His writings indicate that the true principles of masting ships were not understood at that time. He complained of the too great height of the masts; and considered it necessary to state so simple a truth as this:— "A very small sail, but placed at a very great height, does more in causing the ship to incline than in giving to her an onward motion; because, being applied to the long arm of a lever, it has a greater moment in relation to the centre of gravity of the ship; whilst a greater sail, but placed lower, does less to produce inclination; and that does not hinder its producing all its effect as to the velocity of the way, which it accelerates."

"The ordinary rules," he says, "transgress, not only in giving too great an elevation to the masts; they have, besides, an inward and secret fault, in that they do not give the law which the dimensions of the sails in different ships should follow."

"The common rules being found defective, we are not able, and very much is needed, to substitute for them others as simple; but, nevertheless, if we once have a ship whose masts are well disposed, we could make use of her to regulate the masts of others which would be similar. The relative powers which ships have to carry sail, are as the fourth powers of their simple dimensions; and the relative powers which the masts have to overturn the ship, are as the breadths of the sails multiplied by the square of their height, since this height increases the extent of the sails, and at the same time makes their centre of effort higher. On the other hand, we can hardly dispense with regulating the breadths of the sails by the breadth of the ship: we can make these breadths greater or less; but they ought always to depend on the other. Thus, while the relative force of the ship to carry sail is as the fourth power of her breadth, the relative force of the sail to produce inclination, is as the product of this same breadth by the square of the height of the mast. But if these two forces are in equilibrium, there will be an equality between the two quantities which express them; and this equality will still remain if we divide the two quantities equally by the breadth. Now it follows from this, that for similar ships to have their masts equally perfect, the squares of the heights of the masts must be as the cubes of the breadths of these ships, or the cubes of their lengths."

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* "Traité du Navire," Liv. iii., Sec. v., Chap. v.

The practical rules for determining the masting of ships are: " 1st. *In similar ships the squares of the height of the masts ought to be as the cubes of the simple dimensions of ships.* 2nd. *The heights of the masts ought to be proportional to the breadths of ships whose lengths are the same.* 3rd. *In ships of the same bulk, but of different lengths, the heights of the masts ought to be as the square roots of the lengths.* 4th. *In ships of different lengths, and different bulk, the heights of the masts ought to be in the ratio composed of the breadths of the ships, and of the square roots of their lengths, or they should be as the products of the breadths by the square roots of the lengths.*" *

The hydrostatic principle of flotation is stated in the following concise and definite manner.—" A body which floats on a liquid is pressed upwards with a force equal to the weight of the water or of the liquid whose place it occupies." † And the principles of floating and of immersion are investigated in a course of reasoning on the basis of geometrical facts. This leads to a practical method of ascertaining the actual weight of a ship by knowing the bulk of the immersed part. Three methods of measuring the solid content of the immersed part are given: the first was based on the consideration of its being an *ellipsoid;* the second method was by dividing it into a great number of transverse rectangular prisms; the third required simply the division of it by sections.

In connection with directions how to find the position of the centre of gravity of immersion, the author investigates the subject of stability, and the greatest height at which the centre of gravity of the ship may be placed consistently with her safety. But the stability of ships is estimated by determining the height at which the métacentre is placed above the centre of gravity of the ship. The point at which the métacentre is situated, is investigated at some length, and the way to determine this point is enunciated. The principles of relative stability are stated thus:—" In ships which differ only in their lengths, the stabilities are in the same ratio as these lengths. When ships are of the same length, their stabilities are as the cubes of their breadths." ‡

Akin to the last subject is that of the motions of rolling and pitching. The character of these is investigated on the supposition that they are similar to the oscillations of a synchronous pendulum. The whole argument being based on an hypothesis which science does not now acknowledge, there is no need to follow it in its details.

It would be an unreasonable expectation that we should look for a perfect development of principles in the treatise of M. Bouguer. Experience, even, had gone but a little way, looking only at that which is useful, in induction; and science itself was hardly identified with naval architecture with enough of certainty in fundamental principles, to construct any part of theory on a sure basis. The lapse of a century, of which the greater part has been alive to the importance of this subject, leaves much in doubt, and mixed with material error in almost all,—still needing investigation based upon well established facts, as obviously as this was needed when M. Bouguer wrote. The value of his book cannot be estimated fairly without looking at the condition of knowledge when it appeared,—without perceiving the paucity of acknowledged principles and of details which shipbuilders might then depend on as guides; but, viewed in the circumstances of the time, the work is such, however it may have been estimated, as justly to mark a distinct point in the history of the theory of naval architecture.

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* "Traité du Navire," Liv. i., Sec. ii., Chap. vi.

† *Ibid*, Liv. ii., Sec. i., Chap. i.

‡ *Ibid*, Liv. ii., Sec. ii.

In the year 1755, the prize of the *Société Royale des Sciences* was awarded to M. Chauchot, a very learned and skilful naval constructor, for a *Mémoire* on the manner of diminishing as much as possible the rolling and pitching of a ship without her sensibly losing, by this diminution, any of the good qualities which her construction ought to give her.

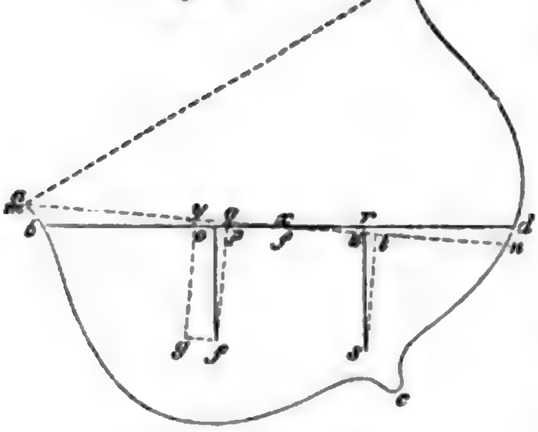
The Society was not satisfied with the extent and results of the investigation; and therefore offered a further prize on the same subject for 1757. The importance of the subject demanded more detailed investigation, and more exactness, than had yet been given to it. M. Daniel Bernoulli, who had, as he tells us, for years made it a branch of his inquiries, engaged in the preparation of a mémoire, based on the principles of hydrostatics and mechanics. He seems, however, not to have perceived that the motions of rolling and pitching required to be investigated as an independent subject; for he introduced the immediate inquiry, by an examination into the principles of statical stability in ships, deeming that the motions of rolling and pitching depended chiefly on this property. We will first give a general sketch of his reasoning on the stability of ships; and as this eminent author has gone further in his investigations than any one had gone before, it will appear how far this part of science was now developed.

He begins the subject by saying,—"Every body floating in smooth water will take a certain determinate position; it is only spherical bodies whose centre of gravity is placed at the centre of the bodies, which are absolutely indifferent to all position. The least force may make these bodies quit their first position, and they do not recover it, although the force may cease to act. In cylindrical or spheroidal bodies, whose centre of gravity must be placed in the axis, there would be only this one axis, which would always take a certain determinate position; but nothing would determine their position about their axis. All other floating bodies take a certain position determined in every way. It is true that the least force makes them quit this position; but, the force ceasing to act, the bodies always return to their position of equilibrium. It is this effort to return to its position of equilibrium which constitutes the stability of floating bodies, and which may be compared with that of a rounded body laid upon a horizontal plain, in a state of equilibrium in proportion as the centre of gravity is below the centre of the curve which is in contact with the plain."

Assuming, then, as known data, the points in which the centre of gravity of the whole body or system of the ship, and the centre of gravity of the immersed part are situated, he states the obvious fact, that the two centres of gravity must be in the same vertical line whilst the ship floats in equilibrium. "But suppose the body held in another position, by forces purely horizontal, we must then draw perpendiculars through the two said centres of gravity, and the distance between these perpendiculars will denote the lever at the extremity of which the weight of the body acts, and endeavours to restore the body to its natural position. If, then, we call the weight of the body *P*, and the distance between the two said perpendiculars *r*, the product *P r* will show the momentum of the force which tends to restore the floating body to its natural position, and which will produce its effect as soon as the foreign horizontal force ceases to act. Thus our question is found to be reduced to that of determining the quantity *r* for each position of the body, whose immersed volume is supposed to be constantly the same. I shall, however, remark here, that this supposition is no longer true so soon as the body is left to itself, as it begins to roll, and as this body will draw alternately more and less water." *

If any common transverse section of a ship (fig. 1), equally thick, be taken, whose line of flotation in a state of equilibrium is *a e*, this line is necessarily horizontal; then, under any lateral inclination of the ship, that line *a e* will form with the inclined water-line *b d*, a certain angle of inclination, with which *b c d* is the immersed volume of the ship; the position of the ship being thus oblique, suppose her to be further inclined at an evanescent angle at which

Fig. 1.



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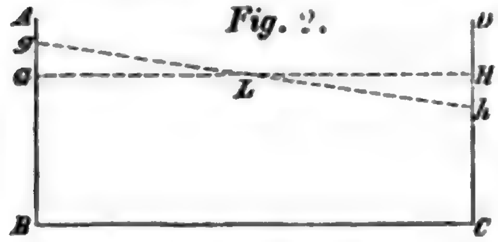
* "Principes hydrostatiques et mécaniques, ou Mémoire sur la manière de diminuer le roulis et le tangage d'un navire, sans qu'il perde sensiblement par cette diminution, aucune des bonnes qualités que sa construction doit lui donner. Par Daniel Bernoulli:" Sec. iii.

the water-line becomes *m n*, cutting the line *b d* in the point *x*, and forming an angle which may be represented by σ, and measured by "an arc of a circle whose radius is unity. The question is to find an equation between the differential $d\,\sigma$ and the increment of the corresponding force." As the immersed volume is a constant quantity, the elementary triangular volume that emerges by the inclination is equal to that which thereby becomes immersed; and at evanescent angles the inclined water-line cuts the natural water-line in a point at which it divides it into two equal parts: that is, $b\,x = d\,x$; and "the small angle *b x m*, or *d x n*, is that which is expressed by $d\,\sigma$. Let the centre of gravity of the section *a c e* be at the point *s*, the centres of gravity of the immersed homogeneous part for the water-lines *b d* and *m n* at the points *f* and *g*. If, after that, we draw from the points *s* and *f* the lines *s r* and *f o* perpendicular to the water-line *b d*, the intermediate line *r o* will be the length of the lever upon which the weight of the section endeavours to restore this section to its natural position in relation to the water-line *b d*; and if, in the same way, we draw from the points *s* and *g*, the lines *s t* and *g y*, perpendicular to the water-line *m n*, the intermediate line *t y* will, in the same way, be the lever relatively to the water-line *m n*; thus the difference between *t y* and *r o* will show the increment of the lever, whilst the weight applied to these levers remains constantly the same. The question then is, to determine the differential $t\,y - r\,o$." The investigation is pursued at considerable length; but, having indicated the principle, we do not deem this the right place to follow the line of reasoning in its development.

The form of vessel to which the preceding observations apply, is such, that at large angles of inclination the inclined water-line would cut the natural water-line at some distance from the middle point. But such form not being the best suited to stability, and to the other good qualities which were especially the object of inquiry in that *Mémoire*, another case was considered, in which the sides of the vessel were vertical (fig. 2): it had been previously shown that the form of the transverse section, below the points which may rise to the surface of the water by the inclination of the ship, does not affect the stability. Considering, therefore, a vessel whose sides are vertical, as A B and D C, between the points which limit the immersion and emersion under inclination, as shown by the line *g h*, M. Bernoulli says, "the stability is here no longer proportional to the sine of the angle of inclination, as when the sides are circular arcs of the same circle; it increases in a greater ratio than the said sine. The more

Fig. 2.



the body is inclined here, the more it resists further inclination; the additions of power to produce continually a new degree of inclination, increase here in a much greater ratio than in the preceding hypothesis." He says further, that "the stability of all floating bodies depends solely upon two things: the first is the horizontal section of the body at the level of the water, and the second is the height of the centre of gravity of the body above the centre of gravity of the immersed part, considered as homogeneous, which height ought to be multiplied by the whole weight of the water displaced."

Bernoulli proceeded then to investigate the nature of the oscillations of floating bodies,—an extremely difficult subject, on which he developed his great genius in the admirable and philosophical manner in which he treated it. If he failed of solving its difficulties, it appears much more just to attribute the failure to the imperfect state of science at that time, than to any defect in his own powers of investigation.

The lateral oscillations of a ship are regarded as being of two classes. The first are those which a ship makes in a state of entire freedom, after having been put in motion by a single impulse: these he calls *natural oscillations*. The oscillations of the second class are those which are produced by consecutive isochronal impulses, and which are therefore themselves isochronal. This conclusion is arrived at thus: "In the first place, I hold as a principle that in every system of bodies which act one upon another, if these bodies make reciprocal, regular and permanent movements, they will always make harmonious and synchronous oscillations, which will begin and end at the same instants." This principle is applied to a ship and to the waves which produce upon it successive impulses at regular intervals,—with the observation, that as the ship can have no influence upon the oscillations of the waves, these will prevail over the ship, and make its oscillations agree with those of the agitated waters, so that the time of each oscillation may be equal to that of each moving impulse. If the principle is correct (and Bernoulli says "it is a truth which I have observed with complete evidence every time I have happened to examine similar reciprocal compound movements"), then the conclusion seems inevitable. At the same time, he justly says, "the rollings depend partly on the force of each impulse, and partly on the interval of time between two consecutive impulses.

In order to illustrate the oscillations of a ship, he took up the idea to which the illustrious Newton had had recourse for measuring the time of transfer and amplitude of waves;—that they will be conformable to those of a simple pendulum. The pendulum supposed by Bernoulli in these investigations was nearly thirteen feet long, and subjected to a force consisting of its own weight, and an external force similar in its effects to the impulsive force of the wind, and causing it to make one stroke in each second of time; and the conclusion to which the investigation led, is expressed in the subjoined concise formula. For, he says, let the greatest intensity of external force be equal to the weight of the pendulum, making an angle S; and let the time of the natural oscillation of the pendulum be t; and let this pendulum be obliged by the external force, to make each vibration in $\frac{t}{n}$; then the pendulum will vibrate through the angle $\frac{s}{n^2-1}$.

He next shows how the pendulum here referred to may be applied to measure the rolling of ships: supposing φ to be the maximum force which acts upon a ship, and that it is constant throughout the vibration, and s the angle to which the ship would be inclined. The increase of stability is recommended as the surest way to diminish the rolling of a ship; and the angle of inclination being expressed by s, we see clearly, he says, that this angle, s, will be the smaller as the stability of the ship is great; and that for small angles, one is reciprocally proportional to the other. Taking π as the expression of the intensity of the stability, we have πs to represent the stability at the angle s; and, therefore, $\varphi = \pi s$, and $s = \frac{\phi}{\pi}$. Substituting this value in $\frac{s}{n^2-1}$, we have $\frac{\phi}{(n^2-1)\pi}$.

Let $t =$ the time of the natural oscillation of the ship; and $t' =$ the time between two impulses; then we have $t' = \frac{t}{n} \therefore n = \frac{t}{t'^2}$; $n^2-1 = \frac{t^2}{t'^2}-1 = \frac{t^2-t'^2}{t'^2}$. By substitution again we have $\frac{\phi}{(n^2-1)\pi} = \frac{t'^2\phi}{(t^2-t'^2)\pi}$.

The object of the next part of the inquiry is the variety of effects produced as the quantities t and t' vary in relation to each other. The above formula expresses three quantities affecting a ship's oscillations;—the force which agitates the ship, her stability, and the relation there is between the times t and t'. It shows that as π is great, the extent of rolling will be small. "It is true," he says, "the time t most frequently depends on the stability; since, if the stability is greater, the natural oscillations of the ship should be thereby accelerated. It may be said that, all the rest being equal, the time t is almost reciprocally proportional to the square root of the stability; but t may be changed without altering the stability. The following observations are made on this subject. If t' is greater than t it is clear, that the quantity $\frac{t'^2\phi}{(t^2-t'^2)\pi}$ becomes smaller as the intensity of the stability is greater, since we may suppose the quantity $t^2\pi$ is almost constant: it is indifferent whether the value of the denominator is positive or negative for the amplitude of the excursion; the difference simply shows whether the forces φ and π act on the same side or on the opposite sides; but if t' is smaller than t we shall, on the contrary, increase the rolling by increasing the stability, because the denominator becomes smaller, supposing the quantity $t^2\pi$ to be always constant. It will perhaps produce surprise to hear that there may be cases in which an increase in the stability causes an increase in rolling. To that I reply, that stability certainly always diminishes the inclination caused by a uniform and permanent force; but that the amplitude of rolling caused by impulses of force does not always determine the said inclination. If t' were infinitely greater than t, the extent of the rollings would be expressed by $\frac{\phi}{\pi}$, and the rolling would be diminished in proportion as the stability was increased. If, on the contrary, t' were infinitely smaller than t, the same extent of rolling would be expressed by $\frac{t'^2\phi}{t^2\pi}$, and the stability would hardly alter the extent of the rolling; besides, the oscillations would in this case be very small of themselves, because of the supposed smallness of $\frac{t'^2}{t^2}$." Such is the theory of a ship's rolling, constructed by that eminent mathematician; and he concluded that part of the subject by stating, that the only case to be feared is that in which the times t and t' are almost equal. It does, however, not appear how Bernoulli thought the principles he laid down should be applied in the construction of ships.

The *mémoire* is concluded by an investigation of the stability of a floating body on a surface of water, inclined at a given angle to the horizon; but the reasoning pursued here is not different from that which he employed on the stability of a ship when the surface of the water is horizontal.

Very soon after Don George Juan wrote his great work in Spain, Leonard Euler produced a work on the same subject in Petersburgh, under the title of "*Théorie Complette de la Construction et de la Manœuvre des Vaisseaux.*" He enters at once, and systematically, upon a consideration of the scientific principles involved in the question of construction. The subjects are so investigated as to vindicate the title which was used; for they are characterized by a completeness of reasoning, based on geometrical principles, with a clearness which shows how satisfactorily mathematical investigation may result, when the subjects under inquiry are sufficiently definite, and the principles of mathematics can be fairly applied to them.

The first important question discussed is that of stability. This is investigated with great care, in a lengthened and lucid statement of principles, and in reasoning based upon them; it considers the form of the body, and the position of its centre of gravity; and, in concluding this subject, this eminent author says,—"With regard to all that we have yet said, we observe, that besides increasing the section of the water, the most effectual means to augment the stability is to carry the centre of gravity as low as it is possible, or that circumstances will admit.*" It is obviously true, that, all other things being the same, the depression of the centre of gravity to the lowest possible point, would determine the stability of the ship at its extreme limit; but experience proves that this extreme limit must not be sought, because the intensity of this force would then make the ship uneasy in her motions, and the strain upon both the ship and her spars would be excessive. Ships are found to be the easiest when the centre of gravity is in, or very near to, the plane of the water-line; whilst, other things being properly determined, the stability is then sufficient.

The motions of rolling and pitching are considered briefly; as it appears, because the subject was one to which theory could lend but partial aid. The oscillations which may be made both in rolling and pitching in a smooth sea, are compared with those of a synchronous pendulum; yet it is seen that those which it is most important to understand could not be successfully investigated by such a comparison; and, after investigating the principles of rolling and pitching in a smooth sea, we find these remarks:—"When the sea is much agitated, we easily conceive that both the rolling and the pitching must suffer very considerable alterations from it, seeing that the alternate rising and falling of the waves themselves are capable of producing a vibration in the vessel, although it had not received an inclination from any other force; but, in order to determine the motions with which the vessel would then be impressed, theory leaves us entirely in the dark, seeing that, on one side we are still absolutely ignorant of the laws by which water agitated acts upon bodies which float therein, and, on the other hand, the expression before found for the stability could no longer have place, for the same reason; and, therefore also, the length of the isochronal pendulum, which we have just assigned, becomes entirely false." †

Euler had previously written on the stability of ships, and his essay gained the prize of the Academy of Sciences in 1759. The drift of his investigation in that production was, the strength a ship should have in order to bear the strains caused by rolling and pitching.

He commences the subject by considering all the parts of a ship as having to sustain the action of a *centrifugal* force in its oscillations; and then the simple force with which two bodies must be held together, subject to one acting power, applied, too, in the simplest manner, the force required to prevent separation being merely sufficient to bear the tension. The reasoning is then extended, and applied to parts combined together in a system, as in a ship; and the consideration of direct and simple actions leads to that of such as are complex and contrary in their tendency.

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* English Translation, Book i., Chap. ix., Sec. 72.

† *Ibid*, Book i., Chap. x., Sec. 78.

The forces exerted on the different parts of the frame, as they are variously placed in relation both to the centre of gravity and to the impulse which produces the strain, had to be determined by the principles of mechanics and by the integral calculus; the results of such investigations are definitely stated, and concise formulæ are given. Nevertheless he says, "The researches in question are not, from their nature, susceptible of a very high degree of precision." *

The common forces of impulse and resistance are investigated, as to the efforts they exert upon the frame, under the two conditions of sailing—directly and obliquely—the sea being smooth. The forces are considered as unequal, and as equal and uniform; and their effects are investigated as to the direction of the strain, and the actual power exerted to destroy the combinations of the parts of the frame; and the effect produced on the frame by a sudden resistance, as that of a rock, is examined. The elementary considerations of this case are thus stated: "The force which the ship experiences by the concussion depends, first, on the mass of the ship, then on her velocity, and, thirdly, on the hardness as well of the ship as of the rock at the place where the shock is made.

"If the two bodies which strike one another were perfectly (or, what amounts to the same, infinitely) hard, so that they were not at all susceptible of the least indentation, their motion must in an instant undergo a finite change, the production of which requires a force infinitely great.

"In this case, then, the force would be infinite, and all the combinations by which the ribs of the ship are fastened together, however strong they may be, must break suddenly; but the ship being reduced by this shock, to a state of rest, in an instant, these infinitely violent shakes can last only a moment." †

The course of reasoning pursued with reference to these premises, to indicate the effect of concussion with any assignable force, needs not be traced.

The next subject of inquiry is the effect of an impulse coming suddenly on a ship, tending to give her an onward movement. As, however, this kind of action is not that by which the strength of the frame should be determined, the way in which the strain acts upon it, and the amount of force so exerted, are but briefly investigated.

The inquiry into the character and effects of a ship's rolling is conducted on the supposition that this motion is caused by a single force, and not, as

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* "Recherches sur le Roulis et le Tangage des Vaisseaux," Sec. xiii. † Ibid, Sec. xxvi.

is actually the case at sea, by a continued succession of forces. Hence the second and following lurches which a ship makes in rolling, are not, as M. Euler considers, simply the effects of the first impulse, but of those which follow. He says,—"When it is required to determine the efforts which the combination of the frame-timbers of a ship experiences by the motion of rolling, two sorts of forces must be distinguished; one which impresses such a motion on the ship, and the other that by which this motion whilst it lasts is accompanied.

"Every force which makes the ship incline on one side about her longitudinal axis, when it ceases to act, impresses on her a reciprocal motion, or an oscillation, which is called rolling. This motion is commonly produced, either by a shock against the sides of the ship, or because the surface of the sea is higher at one side than at the other. In each case the ship must incline towards one side, and, knowing the force which must produce this effect, it will be easy, from the principles which I have just established, to determine the efforts which the combination sustains.

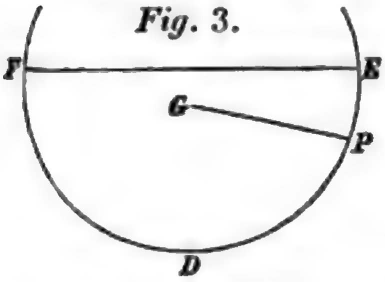
Fig. 3.

"If it is only the shock of one wave which the ship receives on her side, the surface of the water remaining horizontal, the effect of it could not be very considerable in regard to the inclination. For if the shape of the frames were circular, as Fig. 3, F D E, and the longitudinal axis passed through the centre G, the direction of any shock whatever (in P) would pass through the centre, and would not consequently have any moment to incline the ship.

"The same thing would happen if the shape of the frame were a polygon inscribed in this circle; but though the shape of the frame may not have this property, it does not differ from it so enormously that a great inclination may result from it; and it is not worth the trouble to draw from hence a rule for the construction of the frames, which ought to be regulated by much more important rules."

If, however, the surface of the water were not horizontal, but rose higher at one side of the ship than at the other, "the ship," he says, "could no longer be in equilibrium, and must undergo some inclination, its weight being no longer balanced by the pressure of the water.

"As it regards the mathematical determination of the pressure which the ship experiences in this state, it must be confessed that the principles of hydrostatics are not yet enough developed that we may be able to determine from them the pressures of an agitated fluid, or one whose surface is not horizontal."

Without, therefore, making the pressure of the sea exerted in the rolling of waves a subject of inquiry, he says,—" It is not so much the forces themselves which are the most dangerous, as their moments in relation to an axis of rotation; for, however great a force may be (I speak here only of forces which are found in common agitations), if its direction passed through the centre of gravity of the ship, the efforts of the ribs upon the combinations would hardly be cause of fear; but if its direction passes very far from the centre of gravity, the force acquires thereby a great momentum, and will be likely to cause a bad effect, even when the force would not be very great.

" It is easily understood, that although we could not determine the pressure of an agitated sea, or one whose surface is not horizontal, its direction could not be very remote from the axis of rotation, nor its momentum very great. Consequently, since the combination ought to resist much greater moments, there is nothing to fear from the forces of which I am here speaking." *

The supposition with regard to these motions is, that the force is discontinued after the first shock has given an impulse, and that the reaction and the continued oscillation result from this one impulse, and are impeded, and ultimately destroyed, by the resistance of the water, or by some other cause; but as the resistance of the water opposing the motions of rolling is very small, owing to the curved form of a ship's bottom, these motions would be continued a long time, he says, if there were no other opposing force. All this supposes, however, that the ship is stationary, and therefore is not under the balancing power of sail.

Such being the conditions, he says, " The ship will make oscillations similar to those of a pendulum, provided the inclination be not too great, and no notice be taken of the movement of the centre of gravity as it rises and falls alternately; for this movement, being very small, is of no consequence in the present inquiry.

" These oscillations will consequently be isochronal to those of a simple pendulum, whose length is determined by the following very plain rule. Let St be the stability of the ship in relation to the longitudinal axis, and Mk^2 the moment of inertia in relation to the same axis; then this expression $\frac{Mk^2}{St}$ gives the length of the simple pendulum, isochronal to the oscillatory movement of the ship, whilst it lasts.

" These oscillations will then be the more lively as the quantity $\frac{Mk^2}{St}$

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* " Recherches sur le Roulis et le Tangage des Vaisseaux," Secs. xxxii., xxxiv., xxxv.

is less, and if we wish to make the movement slower, we have only to procure a great value to the expression $\frac{Mk^2}{St}$ to make these oscillations isochronal to those of a very long pendulum. To this end we must try to increase on one side the moment of inertia, as much as it is possible, and, on the other side, to diminish the stability $S\,t$; but this last remedy is directly opposed to the other good qualities which a ship ought to have." * The diminution of stability is, therefore, altogether rejected as a remedy, as it would leave the ship so much more under the power of the inclining force, and the rolling would become deeper as well as slower; and as the strain produced on the frame in rolling is greater in proportion as the angle of inclination is great, the effect of such a remedy would be in all respects disadvantageous. He then proposes to increase the moment of inertia by placing the weights as far as possible from the longitudinal axis.

The importance of making the stability of ships great, on other considerations than that of rolling, required this quality to be here left free; and the magnitude of the moment of inertia to be the condition of regulating the extent of these motions; but, inasmuch as the object of this treatise was to investigate the character and force of these motions in relation to the strain exerted thereby on the parts of the frame, and on their combination, the author says,—"As it is not in our power to moderate the impulses, the question is, how to diminish the expression $\frac{m.\,GM}{Mk^2}$, (m being the mass of any part whatever of the frame, $G\,M$ the distance from it to the centre of gravity, and $M\,k^2$ the moment of inertia); besides the increase of the motion by means of inertia, we can still draw, therefore, these rules: 1st. *Not to remove the parts of a ship too far from the longitudinal axis.* 2nd. *To make the most distant parts as light as possible.*

"It is very true that by such an arrangement we should also diminish the moment of inertia; but if we are considering one of the most remote parts, we see plainly that the diminution of its mass lessens the value of $\frac{m.\,GM}{Mk^2}$, notwithstanding the denominator $M\,k^2$ suffers from it also some diminution." †

The consideration of the ship's rolling under sail, includes the supposition of only one impulse from the sea tending to give this motion, the wind acting, however, on the sails, determining the character of the movements, in passing from and returning to the state of equilibrium.

The motions of pitching are investigated in the same way as the motion of rolling, and, on the same hypothesis, of one impulse producing the effect.

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* "Recherches sur le Roulis et le Tangage des Vaisseaux," Secs. xxxvii., xxxviii.

† *Ibid*, Sec. xlii.

But a previous writer, M. Chauchot, had arrived at some conclusions with regard to the pitching of ships; and, in noticing them, Euler, it seems, was led into an additional argument on the subject. The following passage states the question at the basis of this argument.

"The moment of inertia $M k^2$ being much greater in the case of pitching than in that of rolling, we might conclude from our formula that pitching would not be so dangerous as rolling; but, although the shocks which cause the pitching are often heavier than those which produce the rolling, by which the numerator is also increased, this force alone would never be greatly to be feared, and we must seek elsewhere the cause of the ill effects to which ships are sometimes exposed by pitching.

"M. Chauchot believes that he has found this cause in the inequality of the two extremities of a ship, and when the bottoms are too fine in relation to the load-water line, because in this case all the support of the ship being at the line of flotation, however little the waves may escape either at the head or the stern, the ship must pitch in a prodigious manner.*

"There is no doubt that this relation is very well founded; but we must bring it back to the first principles which contain the immediate cause of the effects in question."

"M. Chauchot had here in view principally the immersed bodies which narrow suddenly below the water-line, as well forward as abaft; for then, as soon as the ship inclines, the section made at the water-line becomes suddenly very narrow towards this side; whence, its area being much less in the inclination, the stability will be thereby diminished; consequently the same force will be able to produce a greater inclination, which will contribute much to the increase of the pitching.

"To remedy this defect we have only to give to the immersed body such a form, that when the ship inclines either towards the head or the stern, her section made then at the water-line may not be much less than that which it has in a state of equilibrium; for it is known that stability depends much on the area of the section made at the line of flotation.†"

This subject bears on the form above the load-water line as well as below it, and requires that there should be an exact correspondence between the fore and after bodies, so that when the ship is inclined by the head, the increase in the area of the section at the line of flotation of the fore body should be as much as the diminution in the corresponding section of the after body; and, also, that the same condition should hold in the inclination by the stern.

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* The moments of buoyancy in the fore and after bodies must be made equal, in order to easy and equal motions in pitching and 'scending.

† "Recherches sur le Roulis et le Tangage des Vaisseaux," Sec. I.

This, however, is not all; for Euler says, the sections, when the ship is at her greatest inclinations, should be even greater than the load-water section when she is at rest, "since it is not so much their area which enters into the determination of stability, as the moment of inertia, which would be proper to them, if we conceived of their thickness as infinitely small; this moment of inertia requiring to be taken in relation to the transverse axis drawn through their centre of gravity.

"By this means," he says, "we obtain the advantage that the stability of the ship increases with the inclination, which ought to diminish the inclinations produced by the same force." *

The form which would give the advantage in respect of longitudinal stability would, he says, also supply a greater lateral stability in oblique sailing, and so enable ships to carry more canvass in sailing close hauled: "It is very important to give to ships such a form that the resistance which the sides experience in oblique courses should also produce a momentum which tends to diminish the inclination."

In investigating the characters and effects of the two motions of rolling and pitching, there is this important distinction always observed,—that the resistance of the water being small in rolling, is always disregarded in the calculations, whilst the very considerable amount of that force in opposing the motion of pitching, required that its moment should be always referred to in determining the conditions of moderate and easy motion, and be included in the formulæ.

We return to our author's work on the theory of construction, and find a course of lucid and elegant reasoning on the resistance of fluids. As to practical utility, the theory which is here so beautifully expanded might remain unnoticed, because the basis on which it was constructed has been proved by experiments to be erroneous: first, in 1775, in the series of experiments made in France, by M. D'Alembert, the Marquis de Condorcet, and M. L'Abbé Bossut, to investigate the elements of theories already formed, or to establish data on which accurate calculations might be made; and afterwards in this country by Colonel Beaufoy.

This theory recognises, at first, the principle that water contained in a vessel, at a given height, will run out through a hole in the bottom, with the same velocity that a body falling from the same height would acquire. From this principle, the force with which water falls on a plane surface is

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* "Recherches sur le Roulis et le Tangage des Vaisseaux," Secs. liii., liv.

determined. But in this elementary consideration the water, and not the body, is in motion, contrary to that which takes place with ships under sail. Nevertheless, it is evident that the resistance must be the same, whether the water or the body be in motion, the velocity being alike in both cases, since the action and reaction are equal.

But it is not to a column of water falling upon a plane surface, nor to a body passing through the water, and meeting the resistance at right angles to its plane surface, that the reasoning has to be applied ultimately and for practical purposes; for in all ships and vessels the water meets the opposing surface at an obliquity, and presents a resistance varying in some inverse ratio with the acuteness of the opposing surface of the body to the line of motion. Euler proceeds on the hypothesis that the resistance directly contrary to the motion, is equal to the direct pressure multiplied into the sine of the angle of incidence. Now, as the direct resistance depends on the velocity, this is always assumed to be that which has been already mentioned as being determined on the principle of falling bodies. A definite height is assigned in order to realize this velocity; for Euler says, "We know, both from theory and experience, that the water contained in a vessel whose height is $=h$, will run out through a hole in the bottom with the same velocity that a body falling from the same height h would acquire. And if the letter g denotes the height through which a body falls in one second, we also know the velocity will be such, that it would run through a distance $=2\sqrt{gh}$ in the same time. Since, therefore, this velocity is supposed $= c$, or $2\sqrt{gh}=c$, by taking the square $4gh=c^2$; whence we have the height sought, $h=\frac{c^2}{4g}$: consequently, the force of the resistance which a supposed plane surface $=f^2$ will experience by moving in water with the velocity c, will be $=\frac{c^2f^2}{4g}$; and by this force the surface will be acted upon in a direction contrary to its motion. Hence, we see that this resistance is always proportional to the square of the velocity, and also proportional to the area of the surface itself, so that by this means the resistance is perfectly determined." *

The direction of impulse now under consideration being oblique, the condition of that force is to be regarded somewhat differently. The amount of force meeting a plane surface obliquely being resolvable into two other forces, only one of which offers a direct resistance, it is this to which the reasoning is applied. Let the angle of incidence be $= \varphi$; then, according to this theory, the direct resistance will be equal to the sine of this angle, the whole force being equal to radius. Also let P represent the pressure

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* "Théorie Complette de la Construction des Vaisseaux,"—English Translation, Book ii., Chap. i., Sec. iv.

falling on the surface; then the resistance directly contrary to the motion will be $= P. \sin. \phi$. But as the pressure is great or small according to the velocity, and if, as before, we represent this velocity by c, we shall have, by substituting $c. \sin. \phi$ for the velocity giving the whole resistance, $2\sqrt{hg} = c. \sin. \phi$; whence $4\,h\,g = c^2. \sin.^2 \phi$; and "$h$ (still representing the height from which the velocity would be realized) $= \frac{c^2. \sin.^2 \phi}{4\,g}$; and this, multiplied by the area of the surface f^2, will give the force of the whole resistance called P;" therefore the resistance in a direction contrary to the motion, will be $P. \sin. \phi = \frac{c^2 f^2. \sin.^3 \phi}{4\,g}$.

"Thus, by reasonings both simple and conclusive, we have obtained expressions which show us in all cases where a plane surface f^2 is moved in water with a velocity $= c$, and with an obliquity ϕ, both the total resistance $\frac{c^2 f^2. \sin.^2 \phi}{4\,g}$, as well as that in a direction contrary to the motion $\frac{c^2 f^2. \sin.^3 \phi}{4\,g}$. From the first we see that the total resistance is in a ratio composed first, of the area f^2 of the surface itself; secondly, of the square of the velocity c^2; and thirdly, of the square of the sine of obliquity, or of the angle ϕ. But the resistance in a direction contrary to the motion is in a ratio composed first, of the area f^2; and secondly, of the square of the velocity c^2; but thirdly, of the cube of the sine of the obliquity. It is upon these two principles, known long ago to mathematicians, that we have founded all the theory of resistance which solid bodies, moving in any fluid whatever, have to overcome." *

In order now to show a relation between the direct and the oblique resistances, we take up the supposition, first, of a plane surface f^2 moving directly through the water with a velocity $= c$; secondly, of a plane surface, of equal breadth, moving through the water with the same velocity, and at an angle of obliquity $= \phi$, the length of the plane moving directly being to that of the one moving obliquely as the sine of ϕ is to radius; then the area of the oblique plane will be $\frac{f^2}{\sin. \phi}$. The resistance falling on the vertical plane being $\frac{c^2 f^2}{4\,g}$, and as the resistance on the oblique plane "is contrary to the motion, by substituting $\frac{f^2}{\sin. \phi}$ instead of f^2 in our last expression, it will be $= \frac{c^2 f^2. \sin.^2 \phi}{4\,g}$; therefore these two resistances are to each other as unity to the square of the sine of obliquity." †

The surface of a ship's bow is not of course susceptible of a simple application of this theory; but the way in which it is proposed to apply it, is to divide the surface into many parts, so small that each might be considered a plane surface, and to determine the obliquity of each part in relation to the direction of the motion. As it would require a very tedious course of

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* "Théorie Complette de la Construction des Vaisseaux," Secs. v., vi. † *Ibid.*, Sec. vii.

calculations to determine all these angles of obliquity, and so the mean of them, as the angle of incidence, whilst the result would be so uncertain, as to general accuracy, that little confidence could be placed in it, Euler recommends a simple calculation founded on the proportions between the length and breadth of a ship and the whole "resistance of the greatest transverse section of the body moving through the water in a direction perpendicular to that section," according to the formula $\frac{2\,b^2}{a^2 + 2\,b^2} R$: a representing the half length; b the half breadth, which, he says, "is very nearly equal to the depth;" and R the greatest transverse section. The product of these two quantities is the proportion of the direct resistance that a ship of the given relative dimensions is supposed to be subject to. It is, nevertheless, seen at once, that the form of the foremost extremity of ships may vary indefinitely, whilst the principal dimensions are the same; and hence it does not appear that much confidence could be placed in the results of this form of calculation, even if the hypothesis of the theory had been substantially correct. The hypothesis is not, however, without a practical value: it serves to explain the principles and nature of the resistances which ships have to overcome in their motion through the water.

Inquiry into the theoretical conditions of ship-building was almost wholly confined to the mathematicians of the continent of Europe, engaging scarcely any regard in England during the whole of the last century, until nearly its close, when Mr. Atwood investigated the properties of floating bodies, and deduced his useful theorem for determining the stability of ships; but whilst the treasures of mathematical learning were accumulating with the view to aid this important subject, its extreme complexity admitted of but very slow progress towards useful results; and it is interesting to observe, that whilst the Royal Academy of Sciences in France continued year after year to offer its prizes to the best writers on definite subjects connected with naval architecture, and drew forth the talent and labour of some of the most eminent men of that and of other countries, yet their writings show but a very small amount of results in the improvements of the art. Indeed, the practice of ship-building can hardly be said to have improved from those purely theoretical efforts; and yet, the failure of producing useful results must not be laid entirely to the account of the authors. The extreme difficulty of rendering theory applicable to practice was evident at every effort that was made; but the principles of statical stability had been clearly stated, and a formula supplied for calculating it, as we have seen, by M. Daniel Bernoulli; and, about thirty years after his *Mémoire* obtained the prize, the highest authorities in naval architecture in France were unable to account for a deficiency of stability in three ships that were remarkably crank.* Much of the labours of mathematicians has doubtless been too abstract for the guidance of naval constructors; but when that which is not so was not applied, even in France, where the works were produced, and where much encouragement was given to talented constructors, one inference out of two is forced upon us,—either that the works were not read, or that the education of the naval architects of France was very slender.

It is true enough, that some constructors pay no respect to science, and pertinaciously build ships which must necessarily be very imperfect; but there was a constant effort to produce excellent ships in France, and it would not be quite ingenuous to suppose that there would be an almost universal disregard of truths developed by scientific investigations, if those truths had been current amongst them, in a condition in which they could be used.

Don Juan says that, "Of all the theories of a ship's motions, the most complicated is, without contradiction, that of the rolling and pitching. Without doubt it is for this reason that the most celebrated authors † are satisfied with considering the rolling as the effect of a simple action in a ship, resulting from a small inclination which she might be made to experience, the surface of the water remaining always perfectly horizontal; but it is clearly seen, that in considering the rolling under this aspect, it would not depend at all upon the action of the waves, whilst it is the wave which produces it, and which can both increase and diminish it. This supposition greatly facilitated calculation, and without having foreseen or perceived the errors to which it would lead, the results of it have been adopted without dreaming of the defects of the supposition." ‡

Theories, essentially defective, as this is shown to be, must leave constructors to follow other guides, even if the formulæ which they include could be applied to practical purposes. Don Juan wrote his celebrated work in 1771; but it remained about twelve years unknown in France, and still longer in England. With a very high order of qualifications, both in a scientific education and in nautical experience, he bestowed the most elaborate consideration on the subjects which he undertook to investigate. The vigour with which he conducted his investigations is clearly indicated in the character of his work; and the numerous formulæ interspersed through that work may serve to satisfy us, that if there had been a sufficient quantity of well-defined information then on record, and the fundamental principles on which the whole inquiry had to be conducted had been understood rather as facts than as hypotheses, the subject would have exhibited itself in the result with far more applicability to useful purposes.

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* "L'Art de la Marine, par M. Romme, p. 106."

† Leonard Euler, "Scientia Navalis," Tom. i., Chap. iv., Prop. xlviii.; M. Bouguer, "Traité du Navire," Liv. ii., Sec. iii.

‡ "Examen Maritime," Book v., Chap. vi., Art. 609.

The excellent work on the construction of ships by admiral Frederick Henry Chapman, the Swedish naval architect, has far less to do with theory than some works which had already appeared. The ample experience he had in his profession inclined him to make his deductions rather from experiment than from speculations; and his work bears, therefore, the character of practical utility. This seems to have been the design of the author, for he says in the preface, " The theory which demonstrates the causes of these different qualities, which shows whether the defects that are found in them proceed from their form, or from other cause, is then very important. It may, therefore, be concluded, that the science of constructing ships can never arrive at full perfection, and that we cannot give to them all the qualities of which they are susceptible, unless theoretical and practical knowledge be united.

" To be master of this theory in all its extent, appears to exceed the powers of the human mind; we must then be satisfied with a part of this vast science; that is to say, to know enough of it to give to ships the principal qualities, which I conceive to be,—

" 1st. That a ship with a certain draught of water shall be able to contain and carry a determinate burthen.

" 2nd. That she shall have a stability sufficient and also determinate.

" 3rd. That she shall behave well at sea, so that the motions of rolling and pitching shall not be too quick.

" 4th. That she shall sail well before the wind as well as close-hauled, and that she shall be weatherly.

" 5th. That she shall not be too ardent, and nevertheless shall come about easily."

These were then the proper objects to which this celebrated author gave his attention, and the very concise statement indicates something of the condition of naval architecture at the time when it was written.

Although the work is presented to us in a practical form, unencumbered by analytical reasoning and theoretical formulæ, yet it is highly probable that its author was accustomed generally to submit whatever deductions he might make from experiment, to the test of a rigorous mathematical investigation (still he never gives us such reasoning); and, if so, then he would be no less careful to bring his theoretical deductions to the proof of experiment.

The method of calculating a ship's displacement, had previously regarded the parts of lines between the ordinates as straight lines; but this was an obvious error, and M. Chapman regarded them as parts of a parabolic curve; and from the properties of that curve, and of the trapezium, he obtained an expression for making a calculation which approximated much nearer to an accurate result than other methods had ascertained. It has, however, been shown by Mr. Atwood, that Mr. Stirling's method of approximating to the areas of curves is nearer the truth than that of Chapman, but with so small a relative superiority, that either of them was sufficiently exact for practical calculations. The method of calculation which would approximate to the areas of curves, was of course applied with equal success to determine the solid contents of the body and the position of its centre of gravity.*

It is not necessary to notice the details of contributions which this valuable work has rendered to the science of naval construction; but it is just to observe that the notes added by M. Clairbois, who translated it into French, and by Dr. Inman, Professor of Mathematics at the Royal Naval College, who translated it into English, gave it an additional value, by correcting some errors into which the elementary principles of M. Chapman had led him, by supplying some considerations which he seems to have overlooked, and by elucidating, in some measure, portions of the text.

The efforts of the Academy of Sciences at Paris kept some attention fixed upon subjects immediately connected with naval architecture and navigation, in addition to all that experience of great deficiency urged towards improvement. Mathematicians were therefore looking to science for a basis on which improvement should be carried on; but the speculations of some of them were, as it seems, conducted with too exclusive a reference to abstract principles; for amongst the numerous formulæ that were constructed, in the course of their reasonings, there were few supplied that have been found useful in practice. The union of practical information, with a power to investigate the bearings of facts on the principles of mathematics, led to a different line of inquiry.

About the year 1763, the Chevalier de Borda, a naval captain, and a member of the Academy of Sciences, doubting the soundness of the theory then generally accepted as the basis of naval construction, engaged in a practical examination of the laws of the resistances of fluids, and arrived at some definite conclusions: as, first, that the resistances experienced by bodies moving in the air, and in water, are proportional to the squares of the velocities; secondly, that the resistances opposed to plane surfaces moved in the air, increase in a greater ratio than the extent of these surfaces; thirdly, that the common theory is entirely false, as it regards the resistance experienced by surfaces struck obliquely by a fluid.

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* It is doubtful whether the method used now for calculating the cubic contents of the body gives its exact measure.

In 1767, M. de Borda undertook another course of experiments, to measure the resistance opposed by water to spherical bodies; from these experiments he came to the conclusion, that the common theory of the shock of fluids gave nothing but absolutely false results; that it gave relations much at variance with truth; and that consequently it would be useless and dangerous to attempt an application of them in the art of constructing ships.

The extreme difficulty in making any experiments on ships at sea, closed the door against inquiry in that sphere for which it was necessary to arrive at conclusions. A bare mention of the difficulties seems enough to make it perceived, that such line of investigation must be abandoned. A ship at sea is constantly varying the surface presented to the resistance of the water; the most steady wind is variable in its force; the position of the sails is not sufficiently exact for calculation; and the varying agitation of the sea produces changes which cannot be ascertained, whilst there are often currents of which the direction and velocity are unknown. Hence, it has been seen, by all who have attempted to investigate this subject, that the experiments made to elucidate it must be on a small scale, and in water of which the condition was known. M. de Borda therefore, conducted his experiments under circumstances suited to bring the facts involved in them under the power of calculation.

The results which were deduced from these investigations, shook the confidence of mathematicians and of navigators in the principles which had long been relied on. For, whilst the established rules could no longer be applied in practice, with any assurance of truth, all the principles involved in them fell under distrust. M. de Borda's experiments did nothing positively towards the development of truth. But all saw the desirableness of reoccupying the place of an erroneous and obsolete theory; in order to this, it was necessary to make experiments and observations which should be sufficiently numerous, varied, and well connected, to point out the true laws of the resistance of water, as well as to demonstrate the errors of those which had been attributed to it.

Experiments having this object in view, were undertaken by M. d'Alembert, the Marquis de Condorcet, and the Abbé Bossut. These experiments were performed in 1775, under the most favourable circumstances for investigating the subject that we may suppose were available in France, and entrusted to the care of persons the most likely, for their eminent attainments in science, to do justice to the subject. The question that required to be first determined was, the resistance which fluids offer to bodies in passing through them; whilst the end to be attained, was the improvement of the inland navigation of the kingdom.

The Abbé Bossut says in his report, that, before applying mathematical investigation, they "thought it would be advisable, by means of experiments, either to establish the truth of the elements of the theories already known, or to procure data to serve as a basis for a new solution." The models used in these experiments were altered, becoming, through successive changes, most dissimilar at the extremities. The place where they were made was a large basin, one hundred feet long, and fifty-three broad, and the greatest depth of water in it was six feet. The models were drawn by a line passing from the end of the model through a pulley at the end of the basin, at the same height, with relation to the surface of the water, at which it was attached to the model, in order that the moving force might be exactly in the required line of motion. And all the arragements were made with the view to the greatest possible precision in noting the results. The results obtained were, therefore, of simple motion in smooth water; and the report says, "All experiments on the resistance of fluids may be reduced to the simple motion, in a fluid which is at rest, of a body of a given figure, by means of a weight or any other motive force, and to the determination of the time employed by the body in passing through a given space." But whether, in deducing the consequences of this simple motion, it is not simplifying the question too much to leave friction altogether out of the account, might be doubted. Colonel Beaufoy always deemed an allowance for friction necessary to the accuracy of his deductions. But Bossut says in this report, "The whole friction against the sides, bottom, and rudder, will vanish in comparison of the resistance against the bows."

In carrying on the experiments, the results were very exactly noted, in comparison with the results of calculations founded on existing theory, and the discrepancy found between the two results, showed the relation of theory to truth. From a number of experiments, conducted and noted with great care, this deduction is drawn: "that the resistances experienced by a surface moved with different velocities, in an indefinite fluid, vary nearly as the squares of the velocities; this law will apply both for the direct resistances and for the oblique; but it must be observed that, strictly speaking, the resistance increases faster than the square of the velocity, and the reason for this is easily explained; for as soon as the floating body is in motion, the fluid is divided and displaced; but as this cannot instantaneously be effected, at the commencement of the motion the velocity is gradually accelerated: while it is small, the water is easily displaced, and escapes along the sides of the vessel, so that its surface remains level; but as the velocity increases, there is more difficulty is displacing the fluid, which consequently accumulates before the bow, and forms a sort of bow of fluid, which is of greater or less extent in proportion as the velocity is great or small, and also, of course, in proportion to the size of the solid bow. Also the fluid sinks towards the after part of the vessel; this double effect is the greatest, everything else being constant, when the velocity is the greatest. Therefore, the increase of velocity augments the difficulty a vessel experiences in dividing a fluid."

It was shown also in experiment, that the resistances to plane surfaces were not exactly proportional to the areas immersed, but that they increased "in a rather greater proportion than the areas of the surfaces. It is evident that this would be the case; for the greater the surface is, the greater difficulty must the fluid which is forced before it experience in escaping and recovering its level." Further, it was found that the resistances experienced by surfaces immersed to unequal depths, did not follow the same law as the resistances to surfaces immersed to equal depths. The velocities of these being the same, the resistances increased in a greater proportion than the surfaces first plunged into the fluid; but the contrary was the case with others.

The trials made to compare theory with experience, in respect of the resistances opposed by the water to oblique surfaces, were not satisfactory; they seemed rather to increase the perplexity of the subject, than to supply means for removing its difficulties. "We see that with respect to the law of the square of the sine of the angle of incidence of the fluid on the plane, the results of theory differ more and more from those of experiment, in proportion as the angle in question diminishes. The motive-weights, in oblique resistances, are always greater, according to experiment, than they should be as deduced from the theory. When the angle of incidence was rather large,—as, for example, 63° 28′, and 45°,—the results of the theory do not differ greatly from those of experiment. But where the angle of incidence was 33° 41′, 26° 34′, 21° 49′, or 14° 3′, the difference between the results of experiments and theory were considerable, and increased as the angle of incidence diminished. It is not possible, therefore, to make use of theory to determine the resistances which are experienced in oblique shocks. In the same manner, theory is completely insufficient to determine the resistances experienced by curved surfaces, excepting in the case in which the surfaces do not meet the fluid under small angles of incidence."

But as, in naval architecture, the resistance has seldom to be overcome by a plane surface, meeting the shock either vertically or obliquely, these investigations hardly touched the subject which this science requires to have determined, in order to its perfection. They served no purpose towards finding the solid of the least resistance, as the law of the curvature in such a case was unknown. The principles shown to be nearly true in regard to plane surfaces, which meet the resistance at great angles of incidence, would be of little value here, inasmuch as the limit of their application would soon cease; and the curve gradually diminishing the angle of incidence, would subject any calculations to great uncertainty, even should a complicated formula be constructed and used for the purpose.

But whilst these experiments proved that the existing theories of the resistances of fluids were erroneous, they failed of leading to the reconstruction of any theory. Hence, whatever in naval architecture had been determined by the principles on which those theories were based, was not only found to have been determined in error, but nothing was provided for the correct guidance of art in future. And naval architects were without even an imaginary certainty to direct them in construction. This state of the science showed the importance of further experiments with the view to determine some sure principles which should serve as the basis of a true theory. The resources of science had been tried, and had not supplied the necessary aid; experience had been referred to, and the rules which it had taught were as uncertain as they were obscure. The art of building ships, and of stowing, rigging, and managing them had been much more successfully made the object of definite rules. Theory was, nevertheless, wanted, in order to the perfection of these arts. But M. Romme says, "it seems still to abandon the constructor to a dangerous uncertainty (tâtonnement) and in an obscurity which it cannot dissipate. Far from being able to show which, of all the forms that may be given to ships, ought to make them the fittest for the sea, it can hardly demonstrate the goodness of some parts of the forms adopted."*

Amongst the various qualities entering into the combination necessary to perfection, are those of stability and speed. And, in order to have all the features of excellence justly proportioned, M. Romme suggests the tracing of all the qualities to their source, so that, knowing their respective causes, generally, rules may be formed easy of application in practice; and the essential relations of the several parts be observed in construction. M. Romme, who was deeply interested in whatever tended to advance this science, conducted some experiments at Rochelle, in 1776, with this object, and obtained results, at once curious and important. His researches were directed to the resistances which fluids present to bodies passing through them in a direct course. He says, "the law which determines the form suited to fast sailing and but little lee-way, depends on a knowledge of that of the resistance opposed by the water to bodies moving in it. It is these laws which serve to measure the action of the water on the rudder, to determine the angle of incidence most favourable to its effect, to form the bow and stern, so that they shall easily obey this action, and to fix as well the place as the height of the masts best suited to accelerate the evolutions. Neither is it otherwise, than from the laws of the impulse of the waves upon floating bodies, that any rules can be determined, to render ships easy in rising upon the waves, and to ensure to them easy and regular oscillations, so far as these advantages depend on the external form of ships. Thus it is seen that the qualities of ships are intimately related to the knowledge of the laws of the action of water upon bodies moving in it; and these laws are still very uncertain. In the necessity of knowing them, it has been assumed that some of them appeared sufficiently probable, and plausible reasonings have made it believed that the water opposes to a surface in motion a resistance varying as the squares of the sine of the angle of incidence. This principle, which alone could serve to fix the form of ships, has been the only one yet employed; and experience has shown that there could not but be error in following it. In making use of this principle in calculating the forms, a particular consideration is also introduced, which is not less conjectural. It is supposed that the total resistance which water opposes to a ship in motion, is equal to the sum of the partial resistances which the parts of the bow alone would experience, if isolated, and presented to the shock of the water, they were moved with the velocity of the ship: no regard is had to the after part of the body in measuring the resistances, and it is thought that a ship, after having been subject to the friction of the fluid in a course bringing the impulse on the bow, after having stemmed the column of water which opposes its passage; the after part of the body, whatever it may be, cannot, in following the bow, either increase or diminish the total resistance. Thus, this adopted law prescribes no particular form to the after part of the ship: but another consideration has presented itself, to dissipate that uncertainty. It has been thought that the fluid particles met by the bow of a ship in motion ought to follow the outline of the immersed part to the extremity of the stern; in order, therefore, that they may strike the rudder under a great angle of incidence, it has been decided that the lowest water-lines at the after part should be very fine and very sharp.

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* L'Art de la Marine, ou Principes et Preceptes-Generaux de l'Art de Construire, d'Armer, de Manœuvrer et de Conduire des Vaisseaux, par M. Romme, Correspondent de l'Académie des Sciences de Paris, et Professeur-Royal de Navigation des Elèves de la Marine, à la Rochelle, 1787.

"It is with such a law, and from such considerations, that the form of ships has been determined. Thus, the bow and after part have been formed on principles very different and equally uncertain. The ships which have resulted from these combinations must consequently demonstrate the insufficiency of the art. In fact, let us open the reports of captains who have commanded the most modern ships, and we shall see that ships rarely sail with the difference in the draught of water indicated by the constructor."

The results of calculation in the construction of ships were wrong, together with the trim;—the form of the midship and other sections;—the masts; and the direct and oblique resistances. Ships were deficient in stability, and were doubled, although it was considered that this property could be correctly calculated. Bossut said that stability, "being founded on the laws of the equilibrium of bodies, has been easily submitted to calculation; and by knowing the weight and the distribution of all the parts of a ship designed, the degree of stability which she will really have can be always determined." Thus, whilst the question of the resistance of fluids, constituting one of the principal theories on which the perfection of naval architecture depends, was engrossing a large share of attention, it was *assumed* that another principal theory—that of the stability of ships—was sufficiently known. But whilst special investigation proved one theory to be defective, the other was proved to be so by common experience. For, if it were supposed that the deficiency in the stability of ships resulted from a want of care in calculating that element in construction, still we see that theory did not supply the means of determining to what cause instability was owing in ships already built, and then submitted to its calculations. It seems that there was scarcely a quality that could be ensured to ships from calculation. Some ships, in which the one feature of excellence sought for was swiftness in sailing, were dull sailers; and, as everything else had been sacrificed to gain that quality, the failures were complete. Ships of 116 guns sometimes sailed as well as those of 74; and some of these would sail faster than frigates and corvettes, which had been built expressly for speed. Some ships, built to run well before the wind, were very slow in running, but were fast sailers with the wind abeam, or close-hauled. Some would not hold a good wind without a considerable depth of false keel; others, because they were too ardent, were trimmed very much by the stern; some would not stay in a heavy sea, others would not carry their after-sails in a fresh wind; and in some, the motions were so hard that no kind of stowage could soften them. Some of the defects pointed out had characterized ships for ages, resulting from principles adopted in naval architecture, and proving the necessity of new theoretical inquiries on the subject.

The attention of M. Romme had been awakened to the subject of the resistances of fluids by observing, that when ships were launched, the phenomena were of a more striking character than those which could be observed when they were impelled through the water by the power of wind on their sails. There might be very little in this common observation, considered apart from other things; but when we see that the ideas it suggested accumulated and expanded, leading to experiments and investigations on one of the most difficult subjects in natural philosophy, and almost supplanting old theories, we cannot but recognize a deep and interesting importance in the observance of those simple facts which seldom give rise to more than a passing thought.

These led to a number of experiments, and thence to the construction of a formula for calculating the resistance of water to bodies moving in it. He referred to an experiment reported by Chapman, which seemed to favour his hypothesis; but it is clear that Chapman did not infer from any experiments that the form of a ship's bow was of little or no consequence to the power with which she would overcome the resistance of the water. The fourth chapter of his work on the construction of ships is decisive on this point. After giving the results of experiments made with seven forms of bodies, he says, "The inference which may be drawn from all this is, 1st. That when the motion is slow, the velocity of the body is greater when the sharpest extremity is before, than when the obtuse extremity is. 2nd. That, when the velocity is increased to a certain degree, this body runs through the same distance in equal times, whichever extremity is before. 3rd. That when the velocity becomes still greater, the body runs through the same distance in less time when the obtuse extremity is before: thus it is the velocity of the body which ought to determine the place of the greatest breadth, in order that the resistance may be a *minimum*." * He referred also to an experiment recorded in the memoirs of the Academy of Sciences for 1767, which he considered would support the same conclusion.

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* Traité de la Construction des Vaisseaux, &c., par Frederic Henri de Chapman, traduit du Suédois par M. Vial du Clairbois, pp. 41-2. Edition, 1839.

He then applied his formula to the experiments which had been conducted by the Abbé Bossut; and in 1783 he read before the Academy of Sciences a Mémoire detailing all that he had done. However startling the paper may have been, it seems to have gained a candid attention; and the Chevalier de Borda, M. de Bory, and the Abbé Bossut, were appointed to examine it and report thereon.

After citing the experiments just referred to, and another which the author had made, they say, "From all these examples M. Romme concludes that the resistance upon an arc of a curve is evidently the same as upon the chord of this arc. He believes, also, that he may therefrom conclude that the resistance upon the curvilinear bow of a ship is the same as if the immersed part of the body was formed by right lines drawn horizontally from the bow, and terminated at the midship section. These propositions once established, the author of the Mémoire gives a general formula for calculating the resistance upon this bow thus formed by right lines, a formula which he does not pretend to demonstrate, which he does not even give as applicable to figures very different from one another, but which he believes may serve to compare the resistances on the bows of ships of the same kind. He shows, besides, that this formula agrees well enough with the results of most of the experiments of the Abbé Bossut, and that it agrees equally with that which the author made at Rochfort.

"We think, with the author, that curves but little different from one another, terminated at the same points, experience almost the same resistances; we think, also, that the formula which he deduces in part from this first proposition gives more exact results than the old theory; but we should like this formula to be tried again, by applying it to new experiments, more direct, and made with the greatest care: this is also M. Romme's opinion."

M. Romme therefore continued the investigation of a subject that seemed to promise results of so much consequence; and whilst his chief problem bore on the direct resistance the water opposes to floating bodies, the other conditions of ships were considered in their mutual and dependent relations. He says, "All ships which have stability, and whose lading is stowed with intelligence, commonly have easy oscillations, and but little extended, and behave well at sea. Those which have great speed are steered easily, and never have much lee-way: thus, amongst these qualities there are principal and secondary, that is to say, that some depend so on others that they are direct and necessary consequences of them. Those which are immediately related to stability and stowage are submitted, as they are, to known rules which are simple, certain, and easy to follow. Therefore, the design of labouring to advance the art, ought to have for its object only to know the forms which may be the most favourable to the speed of the ship, and to the action of the rudder. However, this knowledge, separate, if it were acquired, would not alone be a sufficient help to form excellent ships. It would still remain to examine whether the outlines required for great speed could consist with those which are necessary to great stability; for, according to an opinion commonly enough received, these two quantities cannot, in the same ship, at the same time, be carried to a very high degree. Thus the researches which I have undertaken should not aim at determining the most favourable outline for speed; but especially to discover in what relation the resistance which the water opposes to ships, varies when the forms of their immersed body are very considerably different in their curvature and in their capacity. I ought chiefly to inquire whether, in increasing or diminishing the fulness of the water-lines of a ship which should always preserve the same midship section, and the same principal dimensions, the resistance of the water would experience very perceptible changes; and by this means it would become easy to decide whether the water-lines which would be most favourable to speed, would not lose this property in becoming suited to a great stability, and to a convenient capacity, by the increase of their surface." Such was the important problem which it was necessary to solve by experiment.

Before entering upon the series of experiments in which he sought to arrive at the solution of that great problem, M. Romme investigated the relative force of currents under different circumstances, by the use of curved tubes, as a preliminary measure. We need not stop to notice this part of his labours, further than to mention that he obtained results, from which he inferred the relative pressures of water upon the bow and the stern of a ship. Thus, "The after parts of the immersed body are not pressed in the state of motion as they are in the state of rest, and that this diminution of pressure takes place, not only for surfaces to which the direction of the motion is perpendicular, but also for those to which this direction is more or less oblique. Further, the pressure of the water upon the anterior parts of a body in motion is the more increased as the velocity of the body is greater."

The inquiries must necessarily be pursued in connection with a body moving and pushing away the water before it, in order to make room for itself to occupy, in its progress. It is evident that the water may escape from before a body, more or less easily, according to some conditions. Experiments had shown that the escape of the water from before a body was almost entirely lateral; the determination of that fact was of some consequence, in so far as it narrowed the limits of the inquiry.

Fig. 4.

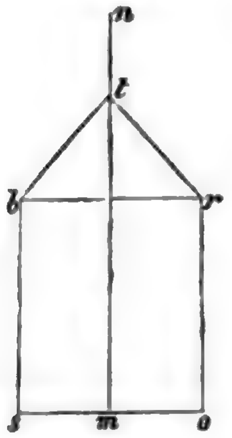
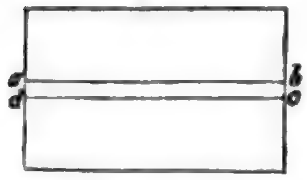


Fig. 5.



Let a prism (fig. 4) " be put into motion by any weight P, this body yields to the power which draws it; it pushes up the fluid, advances into the space, and its velocity is accelerated by degrees, until the resistance, which increases successively, becomes equal to the moving power. When a prism, such as fig. 4, is in a state of rest, the pressure of the water upon its anterior face in a horizontal direction, or perpendicular to this anterior face, is in equilibrium with the horizontal pressure which the water exerts upon its posterior face. This equilibrium is the only cause of the rest of this prism; but as soon as it acquires a velocity in a direction perpendicular to the plane of one of its faces, the anterior fluid is forced up. The water which surrounds the posterior part is pressed by the surrounding fluid to follow the body in its course; thus it no longer exerts any more than a diminished pressure; let $b\,r\,o\,s$ (fig. 4) be a horizontal section of this prism, whose anterior surface is represented in fig. 5; let p be the depth at which this section is placed below the level of calm water, and h the height to which the uniform velocity of the body is due. If this prism is divided by many parallel sections infinitely near to each other, it may be regarded as composed of an infinity of laminæ, which are so many parallelopipeds, whose base is $b\,r\,o\,s$ and height $b\,c$; and it will be necessary to determine the partial resistance which the water opposes to each of these laminæ, in order to conclude therefrom the total resistance which the prism experiences in its motion. Let a represent the side $a\,b$ of the base of these small elementary prisms, of that which is exposed to the shock of the water, and let dp, which is the differential of p, represent its height $b\,c$ (fig. 5); the element of the face of the prism exposed to the shock of the water is then $a\,dp$. When the prism is at rest, the pressure on this element is proportional to p; but as soon as the body is in motion, as soon as this face pushes directly against the anterior fluid, with a velocity due to the height h, then the pressure of water on each element $a\,b\,c\,d$ is increased, and it is in the ratio of $p + h$; for the anterior particles are forced to escape before the body with a velocity due to this same height h, and consequently their pressure on $a\,b\,c\,d$ must become proportional to $p + h$. The pressure upon an element of the anterior face of the given prism is proportional to the weight of a fluid column whose height is equal to the distance from this column to the level of the water, increased by the height to which the progressive velocity of the body is due.

"Let K be a constant depending on the tenacity of the fluid, and on its specific gravity; then the pressure upon each element $a\,b\,c\,d$ of the anterior face of the prism, should be represented by $Ka\,(p+h) \times dp$. The pressure of the water upon the two lateral faces of this prism, are equal and opposite: thus let us examine only what is the pressure which the water exerts upon the posterior face of the horizontal lamina. This face is $a\,b\,c\,d$, equal to the anterior face. As soon as the body acquires velocity, the fluid particles which, in a state of rest, were in contact with the posterior face and the whole of the prism, can no longer, altogether, follow the body which escapes from them. All those which are not capable of taking a velocity due to the height h, because they are distant from the level of the water by a quantity smaller than h, can no longer accompany the body in its course. The body leaves them behind; they no longer exert any pressure upon it; and the fluid sinks behind the body below the level of even water. Things being in this state, it follows that the inferior particles are less pressed, either because the upper columns to which they serve as a basis have diminished in height, or because the inferior fluid is forced by the whole mass of surrounding water to yield to this defect of pressure, and to take, vertically, a velocity due to the height h. The partial pressure which $a\,b\,c\,d$ experienced in a state of rest, and which was proportional to p, ought consequently, in a state of motion, to be proportional only to $p-h$, by virtue of this first cause. I call it first, because a second is joined to this, to diminish the pressure of the water upon this element. In reality the body escapes horizontally before the particles which are in contact with this element. They may then take, as they actually do take, the velocity of the body. Their pressure is then diminished in the ratio of the height due to this velocity; and, taking all these considerations together, the pressure of the water upon the element $a\,b\,c\,d$ of the posterior face of the prism which moves with the indicated velocity, should be equal to $Ka\,(p-2\,h)\,dp$. This force is contrary to the pressure of the water upon the anterior face of the supposed lamina; thus, the total pressure which the water exerts upon this lamina is expressed by $3\,K\,a\,h \times d\,p$.

"If this formula expresses the total pressure of the water upon the outline of an elementary lamina of the prism, it is not the complete expression of what is called the resistance of the water. This, as M. d' Alembert says, is the force by which bodies that move in fluids are retarded in their motion. The supposed lamina experiences from the foremost to the after part a pressure $3\,K\,a\,h\,d\,p$, which opposes its motion, and which must be overcome by the moving power; but if this prism, after having acquired its uniform velocity in an indefinite fluid, were carried by its motion, and by the continued action of the same moving power, into a canal whose breadth should be little different from its own, if this body were forced to advance in this canal, would its acquired velocity remain the same, although nothing might be changed, either in the moving power or in the number of fluid lines which press the anterior and posterior faces of each lamina? It is seen that the fluid particles placed in the line of direction of the body would no longer be able to move in this new position to escape laterally, as in an indefinite fluid. They would be forced to escape before it with all the velocity that it could take: they would then experience greater difficulty in making their retreat, and would contribute to retard the primitive motion of the prism. The resistance which the water opposes to a horizontal lamina in motion, is then in the ratio, not only of the force which results from all the pressures of the water upon its outline, but also from the difficulty with which the anterior fluid makes its escape, to leave a free passage for the body. Let us develop this second cause of retarding the velocity of bodies moved in a fluid. In fig. 4, let the line *m n* be drawn, which indicates both the direction of the prism, and that of a vertical plain which divides this body equally in the direction of its length. The anterior fluid which opposes the motion is also divided by this plain prolonged, into two fluid masses, which are equal and equally disposed with regard to the two halves of the anterior face of the body. Let us consider a particle placed at *c*. The body which tends to advance into the space, presses it to retreat before it; it (the particle) then presses all the particles which immediately surround it, and these transmit this impulse to all the surrounding fluid. This pressure extends itself successively, and is communicated equally in as many directions as we can imagine radii drawn from the point *c*, as a centre, to the various points of the semi-circle *b t r*. Immediately, all the fluid which is before *b r* is divided equally on the two sides of the plain which passes through *m n*. The particles which are in the angle *n c r* escape in as many directions as radii can be drawn from the point *c* to the arc *t r*, of 90°, and the mass which is in the angle *t c b* escapes in the same way to the left of the body. It is thus that all the fluid is arranged and escapes, to leave a free space for the body, which an external power obliges it to occupy. If the number of directions in which the fluid mass enclosed in the angle *n c r*, tends to make its escape were not so great; if each particle such as *c* could transmit the impulse which it receives from the body, upon only a smaller number of radii drawn from *c* to a part of the arc *t r*, there would be fewer particles moved in the same time, their escape would be slower, and the body would experience more difficulty in running through a given space. Thus the force which retards the motion of a lamina, such as that which has been considered hitherto, is in the direct ratio of the total pressure already found, and in the inverse ratio of the number of directions in which the fluid that it pushes up can make its retreat. We have said that the fluid which is before this lamina must be divided in its escape, into two fluid masses; thus, the particles which touch its anterior face, being regarded as so many centres, that transmit in all directions, and far, the impulse which they receive, can make their escape in as many directions as one can imagine radii drawn from the centre c to the arc tr, of 90°. It must, however, be remarked, that such of these particles as are placed upon the sides b and r, of the anterior face of the lamina, have more facility to escape than those which are in the middle of this face; but it results therefrom, that the vertical fluid columns which correspond to the middle of the entire face of the prism extend farther than their *collaterals*, and the fluid which cannot escape quickly enough at the sides, in lines parallel to this face, rises and spreads upon the surface of the water. There is then a great diversity in the escape and motion of the particles which are in contact with the anterior face of the supposed lamina; but all considered and weighed, if we take a mean between all these varied effects, we shall conclude from them, that the resistance opposed by the water to the elementary lamina of the supposed prism is well enough expressed by the relations indicated before. It ought then to be represented here as proportional to the quantity $\frac{3Kahdp}{90}$, and, consequently, the total resistance experienced by the united laminæ which compose the prism ought to be expressed by $\frac{3Kh}{90}\int a\,dp$.*

"Let us now consider how the water resists prismatic bodies when their anterior face is covered with a bow composed of two vertical plains, which together form a greater or less plain angle. These plains are placed with regard to the base of these prisms, as the lines tr and tb with regard to br (fig. 4). The lines tr and tb are equal, the angle tcr is always right, and the angles trc and tbr are variable. The different magnitudes of these

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* This integral must be integrated between the limits $p =$ the whole depth of the body and $p = h$. After this we must integrate the following $\frac{K}{90}\int a\,(p+h)\,dp$ between the limits $p = h$ and $p = -h$. If we put c for the depth of the prism, we shall have, for the whole resistance, both positive and negative—

$$\frac{3Kh}{90}\int_{h}^{c} a\,dp + \frac{K}{90}\int_{-h}^{h} ap\,dp + \frac{Kh}{90}\int_{-h}^{h} a\,dp$$

according to the principles investigated by Romme.

last, alter the angle of incidence of the water upon the vertical plains, or upon the faces of the bow of these prisms. We will here suppose that the posterior faces of these prisms remain such as they have been already considered, and remark that the figure *b t r o s* is that of each horizontal section of these new prisms.

"Let us now seek the proximate expression of the resistance experienced by an infinitely thin and horizontal lamina of one of these prisms, supposing that the base of it, which is the section *b t r o s*, moves directly in the line *m n*.

"This expression ought to be determined, so that, being given, the resistance experienced by a lamina of a prism whose base is *b r o s*, we may conclude therefrom the resistance upon this lamina covered with an angular bow and whose base is the section *b t r o s*.* For if it can become of any use, it ought especially to serve to compare resistances and to fix their relations and that of their variations; when it shall have been rendered general, it ought to show the relation which exists between the resistance that would be experienced by the midship section if it were exposed immediately to the shock of the water, and that which this same section would experience, if it were covered with a bow and a stern either angular or curvilinear. It is this interesting relation which, being well known, can alone accelerate the progress of the art, since it is suited to point out the forms most advantageous to the speed of ships.

"Let us return to the supposed prism. When it is at rest, the pressure of the water upon *b t* in the direction perpendicular to *b c*, is equal to that which *b c* would experience immediately. Let *b c* be represented by $\frac{a}{2}$; when the body is in motion, with a velocity due to the height h, if *b c* struck the fluid immediately, the pressure which the water would exert upon this side would be proportional to $(p + h)$, but that which *b t* experiences is not so great. In effect, let us resolve the motion of *b t* in the direction *m n*, into two others, the one perpendicular to this side, the other parallel; *b t* pushes up the fluid in the ratio of the first velocity, and it slides in the water only in the ratio of the last. Since the velocity, in the direction *m n*, is due to the height h, and if i is equal to the angle of incidence of the water upon *b t*, the velocity perpendicular to *b t* is due to the height $h \sin^2 i$. Then the pressure of water upon *b t* in motion is proportional to $(p + h \sin^2 i)$. The fluid which *t r* pushes up acts with the same force, since the circumstances and the forms are the same; then the pressure upon the two anterior faces of the elementary lamina of the supposed prism, is $K a\ (p + h \sin^2 i)\ dp$, seeing that the posterior face has undergone no alteration in its form, relatively to the shock of the water, the pressure upon this face will be as before, $K a\ (p - 2h)\ d p$. Thus the pressure of the water upon the whole lamina is expressed by $K a h\ (2 + \sin^2 i)\ d p$.

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* The expression ought to be determined, so that the resistance experienced by a lamina of a prism, whose base is *b r o s*, may be inferred from the resistance upon the lamina covered with an angular bow whose base is the section *b t r o s*.

"The resistance which retards this lamina, in the motion which a weight tends to communicate to it, depends, as we have already demonstrated, not only on the magnitude of the pressure already found, but also on the greater or less facility with which the particles pushed up retire from before the body. The expression of this resistance being required to be used in comparing those which both $b c$ and $b t$ experience, let us imagine the anterior fluid divided into fluid threads, parallel to $m n$, and then the threads corresponding to $b t$ or $b c$ are the same in number. If now, we remember that the fluid mass, comprised in the angle $n c b$ has a facility to escape laterally in proportion to the number of directions or of radii which can be drawn from the point c in the angle $b c n$, we shall conclude therefrom that the fluid mass enclosed in the angle $n t b$ is greater; for the fluid particle which is at t being pressed by the body which advances, presses, in its turn, all the surrounding particles which may escape in all the directions that we can imagine between the lines $t n$ and $t b$. The facility of the escape of this fluid mass pushed up by $t b$ is then in the ratio of the magnitude of $b t n$ or of $(180° - i)$. Then the resistance which the water opposes to the elementary lamina of the prism is expressed by $\frac{K a}{180 - i}\ (2 + \sin^2 i)\ d p$; and, finally, the total resistance experienced by all the united laminæ of a prism terminated by an angular bow, is expressed in a very proximate manner by $\frac{K h\ (2 + \sin^2 i)}{180 - i} \int a\, d p$.[*] We see that if the angle of incidence were right, if the angular bow disappeared, and if the prism were reduced to the state in which we have considered it above, the expression of the resistance would become $\frac{3 K h}{90} \int a\, d p$; that is to say, such as that which has been found."

Hitherto the reasoning has had reference only to bodies terminated by right lines. The formula was applied to the results of a great number of experiments which had been performed by the Abbé Bossut, upon bodies with plain angular bows, on which the angle of incidence varied from 84° to 6°; and the results of calculation, by which the velocities under the variations of form were changed, were in all cases so near to the facts, as to satisfy the commission, appointed by the academy of sciences to consider them.

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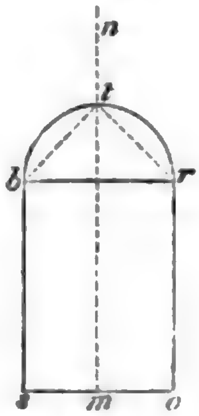
[*] The same remarks in note p. lviii, with respect to the limits of the integral, will apply to this integral.

With principles thus expanded and so applied, the application of the formula to curved surfaces was evidently practicable, though it would be something more complicated. "In order, therefore," M. Romme says, "to proceed with the greatest order, let us first consider the resistance which the water opposes to a body which is the least unlike, in its form, the bodies already examined; I wish to speak of prisms which have a semi-cylindrical bow. The section of the half cylinder is *b t r*, fig. 6. Let us decompose the arc *b t*, of 90° into small rectilineal elements, the pressure of the water upon each of these elements, in motion, and regarded as isolated, would be proportional to $(p + h \sin^2 i)$, the preceding denominations being preserved, and regard being had to the considerations which have elsewhere led us to similar results; *i* is the angle which each element forms with *m n*, and which is the supposed direction of the motion of the body. This angle varies for each of these elements. It is zero at *b*, and it is equal to 90° at *t*. Its value at each intermediate point of *b t* is measured by the arc comprised between the point under consideration and the extremity *b*. Thus the arc *b t* being divided into equal elements, the angles *i*, which correspond to them, ought to increase from *b* to *t*, according to the natural progression of numbers. The fluid particles which are in contact with *b t*, are then pushed up differently by these several elements. The facility of their retreat should then vary at each point of this outline: but does each of these particles in particular obey these different pressures, and can they make their escape in divergent directions? Ought we not to presume that these particles, being contiguous, transmit their different pressures at the same moment? that these pressures unite together to form one mean pressure, by which all the surrounding fluid mass is forced to escape without dividing itself? That in this mass, the parts which would be placed so as to obtain a more easy escape, share with their *collaterals* which touch them, without discontinuity, greater difficulty than these ought to experience in their escape, owing to their less advantageous position? And, consequently, may we not think that these reciprocal communications, which appear to be established with so much reason, on the great mobility of fluid, extending themselves suddenly one after another, all the surrounding fluid mass ought to make its retreat as if it had been struck under an angle of incidence, which should be the mean between all those which correspond to the several elements of the bow of the body?

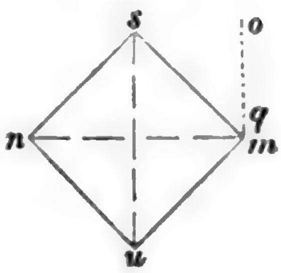
Fig. 6.



"A prism put under experiment by the Abbé Bossut had a plain anterior surface, whose form was a parallelogram. Its breadth was 19 inches 8 lines, and it was tried at successive draughts of water, of 7 inches 10 lines, 12 inches 5½ lines, and 15 inches 10 lines. This face was covered with a semi-cylindrical bow; it had before received an angular bow, formed by two vertical plains, which made together, as the lines *b t* and *t r*, an angle of 90° (fig. 4); these lines were thus the chords of the section of the half-cylinder, and each of them subtended an arc of 90°. If we take a mean between all the angles of incidence of the water upon each element of the arc *b t* (fig. 6), when the body is moving from *m* to *n*, we find that it is 45°, because of the uniform and continued increase of these angles from *b* to *t*. Let us now remark that the angle of incidence upon the chord *b t*, or upon the faces of the angular bow, is also 45°; thus making use of the formula which represents the resistance of the water upon the angular bow; to express also the resistance experienced by the same prism covered with a semi-cylindrical bow, these two resistances ought to be obviously equal, and this relation is that which experiment has made known. Moreover, if we calculate the duration of the movement of the prism covered with its curved bow, by the formula $\frac{K h\,(2 + \sin^2 i)}{135}\int a\,dp$, which agrees with its form, we find that the time ought to be 10·81 half-seconds, and this time was observed 10·84. The body being put at another draught of water, ran through E in 11·6, and calculation gives 12.

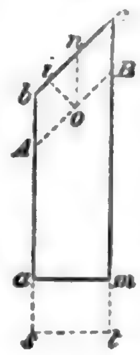
"This equality of resistance upon two bows, so different in form and volume, as the half-cylinder and the triangular prism, which successively covered the anterior face of the prism, leads to consequences as direct as they are interesting, upon the relation of the capacity of the bow of a ship to the property of sailing well. It foreshows that the first may be varied considerably without injuring the second; but the analogy is not great enough between these bodies and sea-going ships to give us all the confidence that is necessary in these premature conclusions, and our considerations must be extended to bodies less different from ships.

Fig. 7.



"Hitherto we have considered bodies whose after parts were formed with plain faces, to which the direction of the motion was perpendicular. Let us now imagine that a prism is formed with an angular bow and an angular stern, and that its horizontal sections are represented by *s n u m* (fig 7). Suppose it to be divided into an infinity of horizontal laminæ, whose very small height is dp: the pressure upon the anterior part *n s m* of such a section, when the motion is directed according to *u s*, has already been found from $K a\,(p + h \sin^2 i)$; it remains then to find the pressure of water upon the angular stern *n u m* of this same section. It is different from that which the line *m n* would experience directly. In fact, let us consider, as before, the whole fluid mass which envelops the after part of the body when it is at rest. Equilibrium then prevails between all the moveable parts of this mass, but it is disturbed as soon as the body acquires a velocity due to a height h. For example, the particles which enveloped the parts near the water-line, at the stern of the body, cannot all follow in its course; those whose depth below the level of the water is less than the quantity h, can take such velocity only as is due to their depth; thus, they remain necessarily in the rear of the body, and it becomes in this part a diminution h of the surface of the fluid, below the general level of the distant and tranquil fluid. The pressure of the inferior particles is then diminished by a quantity proportional to the quantity h; it is then, in consequence of this first cause, no longer proportional to more than $p - h$. A second cause is joined to this first, to diminish the pressure of the water upon the after part of this section; in effect, let *c b a m* (fig. 8) be a half section of a body which is moved in the direction *c m*, and which is terminated abaft by two vertical plains, each of which is inclined to the direction of the motion, as *c b* is to *c m*. Let *c b a m* be the place of this section in space in one instant, and *B A s t* that which it occupies in the following instant. The side *c b* of the after part is thus transported to *B A*, and its direct motion on being decomposed into two, the one, *i n*, parallel to this side, and the other, *o i*, which is perpendicular to it, the fluid, which was in contact with *b c* in the first instant, follows this side in its motion, by taking the shortest course *o i*, and its velocity which is then represented by *o i*, is due to a height $h \sin^2 b$; b is the angle *b c m* of this side, with the direction *c m* of the course of this section. The pressure of water upon the after part *c b*, is then diminished again by a quantity proportional to the height $h \sin^2 b$. Thus, returning to the elementary and horizontal lamina of the body whose section is *s n u m*, fig. 7, and putting together all the pressures which the water exerts upon the bow, as well as upon the stern of this lamina, regard being had, besides, to the facility of the fluid's escape, we find that the water opposes to this isolated lamina a resistance which is expressed in the nearest manner by $\frac{K a h d p (1 + \sin^2 i + \sin^2 b)}{180 - i}$."

Fig. 8.



If the angle i is equal to the angle b, then the total resistance upon a lamina will be proximately expressed by $\frac{K a h (1 + 2 \sin^2 i) d p}{180 - i}$, and the total resistance of the water upon the whole body, by $\frac{K h (1 + 2 \sin^2 i)}{180 - i} \int a \, d p$.

Amongst the various experiments by which the formula was tried, the most remarkable, perhaps the most important, were those made with a model of a ship of the line, constructed on the scale of one inch to a foot, whose entire outline was perfectly conformable to that of the ship;—with a model whose principal dimensions, with the area and form of the midship section were the same, but whose water-lines were all formed of right lines drawn from the stem and sternpost respectively to points on the outline of the midship section, and which were, therefore, the chords of the curvilinear water-lines in the perfect model;—and also a prism whose base had the same area and form as the midship section of the models.

Regarding the two models, which M. Romme calls *perfect* and *altered*, he says, "it would be difficult to imagine that there could be any equality in the speed of these two models: nevertheless, experiment has demonstrated that in putting each of these models at a draught of water of nineteen inches, which corresponds to nineteen feet in the original, as well as at a draught of water of fourteen and sixteen inches, the water opposes to each an equal resistance in the same circumstances, in spite of the dissimilarity of their forms, and the enormous difference of their capacity."

The prism, whose base was that of the midship section of the model already mentioned, was fourteen feet long; and its use was to determine the resistance opposed to a model with plain anterior and posterior faces which formed a right angle with the line of its motion, in relation to the resistance opposed to a body with the same area and form of greatest transverse section with the bow and stern on which the water would strike obliquely. "The expression of the resistance which the water opposes to this prism is $\frac{3\,K\,h}{90.}\int a\,d\,p$. Let us now seek that experienced by the exact model of the *Illustre*. The water-lines of this ship are regular and continued; thus, as we wish to find only the proximate expression of the resistance which the water opposes to this model, it is necessary to calculate the angle formed by the direction of the keel, and by the chord from the anterior part of each water-line; to take, afterwards, a mean between all these angles, and so we shall have the mean measure of the angle i, which must be employed in the compound formula. We shall calculate in the same manner, the mean angle b, corresponding to the after part of the model; and, as the $sine^2\,b$ does not differ considerably from $sine^2\,i$, we shall regard them as equal, and the expression of the resistance which the water opposes to the perfect model of a ship of the line, will be $\frac{K\ H\,(1\,+\,2\sin^2 i)}{180-i}\int a\,d\,p$." As the rectilineal water-lines of the altered model presented to the water the same mean angle of incidence as the mean of all the chords of the elementary arcs of the perfect model presented, the expression for the total resistance of the models was the same. And it has been noticed, that their actual velocities, under like circumstances, were equal.

"The prism of which I have spoken, being put in motion, opposed directly to the shock of the water a face equal and similar to the midship section of each model. When its draught of water was nineteen inches, it ran through the space *E*, of seventy-five feet in 36·5″: the perfect model, at the same draught of water, and acted on by the same moving weight, ran through the same space in 16″. The resistances of these two bodies ought to be equal, since the moving weights were the same;—thus, there ought to be equality between the formulæ which represent them, and and which are, for the prism $\frac{3\,K\,h}{90}\int a\,d\,p$, and for the perfect model $\frac{K\;H\,(1\,+\,2\,\sin^2 i)}{180 - i}\int a\,d\,p$. We have then, $h\,(180 - i) = 30\,H\,(1 + 2\sin^2 i)$. If now, we take for a basis the 36·5″ which are the duration of the motion of the prism over the space *E*; if we afterwards set up upon the plan of the *Illustre* all the ordinates of the midship section divided into laminæ of two feet high, and measure the distance from this section to the stem; if we then calculate all these angles *i* corresponding to each lamina, we shall find that the angle which constitutes the mean between all these angles *i*, which vary from 11° 9′ to 16° 33′, is 14° 41′. These values being substituted in the preceding equation, calculation shows that the time of the model's motion over the space *E*, ought to have been 16·31″; and this is very nearly that which has been really observed.

"The prism and the exact model have also been put to a draught of water of fourteen inches. In this state, the first ran through *E* in 30·1″, and the exact model ran through it in 13·6″. If we repeat here the operations indicated before for the draught of water of nineteen inches, the mean angle *i* will be found to be 13° 58′; and the time of the motion calculated by this formula is then 13·53″,—a quantity which differs but little from observation. We see here, that a difference of five inches in the draught of water establishes, between the bodies of the perfect model in these two states, a very considerable dissimilarity of form; nevertheless, the agreement of the theory and experiment is supported in these comparisons; and the formula might have served to foreshow the duration of the motion of this model. Let us again examine the results which it gives when the after part of this perfect model is covered with a prism which has for its base its midship section. The duration of the movement of this body thus transformed changes in magnitude. When it was at 19 inches draught of water, this model, with its prismatic after part, ran through *E* in 22·48″. The resistance which it experiences in this state, ought, according to the preceding principles, to be expressed by $\frac{K\,H\,(2 + \sin^2 i)}{180 - i}\int a\,d\,p$; thus, by substituting in this formula the data which agree with this draught of water, and forming a relation of equality between this resistance and that which the prism experiences when it is put in motion by the same moving weight, we have $30\,H\,(2 + \sin^2 i) = h\,(180 - i)$: and the duration of the motion resulting from calculation is 22·34″. This model transformed, being at fourteen inches draught of water, was also put under experiment, and moved by the same weight which made the prism run through E in 30·1″; the duration of its motion was observed to be 19·2″; and calculation gives 18·4″.

"These last experiments, and the formula which happily enough explains them, demonstrate a phenomenon truly new; it is the influence of the form of the after part of a body upon the magnitude of the resistance which the water opposes in its motion. This discovery is so much the more interesting, as it is extremely essential for nautical men to know how the water acts upon the after part of a ship; how it alters its speed, and the effect of the rudder."

It would have been hardly fair to the eminent author under consideration, to have epitomised the arguments which he used in demonstrating his proposition. It has not, however, seemed necessary to quote more of the experiments by which he put his formula to the test than sufficed to illustrate its use. The Royal Academy of Sciences twice appointed a Commission to consider the mémoires which M. Romme presented on this subject. The members forming this commission were of the first eminence in the science they had to consider: the chevalier de Borda, M. de Bory, and the Abbé Bossut. The consideration of M. Romme's labours may be closed by some passages from their second report to the Academy in 1785, upon his second mémoire: for, although in the "Art de la Marine" the science of naval architecture is treated of generally, yet it is the first chapter, on the resistance of fluids, that gives a character to the work.

"It is two years ago that M. Romme presented a mémoire on the resistance of fluids, which has attracted the attention of the academy. The author concluded from some experiments reported in that mémoire, that the resistance of the water upon the bow of a ship depended very little on the form of that bow, and that it was always almost the same, whatever might be that form, provided the midship section of the ship were not altered. The commissioners named by the academy found that this result, both singular and very different from all that had been hitherto believed on the resistances of fluids, required to be confirmed by experiments made on a little larger scale; and it is in conformity to their views that the author has made those of which we are going to give an account.

"M. Romme thought that, in order the better to accomplish the object which he proposed, it was proper to compare two bows, very different one from the other, and which should be, so to say, the extremes in construction. He had two bodies made for this purpose by select workmen at the port of Rochefort, the first of which was an exact model of the *Illustre*, a 74-gun ship, on a scale of one inch to a foot. This model was about fourteen feet long, and three feet eight inches in its greatest breadth. The second had the same midship section, the same stem, and the same sternpost, but its bow was formed by right lines drawn from the midship section to different points in the sternpost and in the stem; thus the forms of these two models differed much more from each other than any ship differs from another.

"M. Romme has compared the resistances of these two models at different velocities and at different draughts of water. He made these experiments in a canal forty feet broad, and from seven to eight feet deep.

"The result of these first experiments was, that the two models, at an equal draught of water, and moved by the same weights, always experienced the same resistance. M. Romme found again, that in drawing successively, first by the stem, and afterwards by the sternpost, that model whose surface was formed by right lines, the resistance was the same. Finally, having cut the two models into two equal parts, and having joined the fore part of the first to the after part of the second, and the fore part of the second to the after part of the first, the two bodies always ran through their space of seventy-five feet in the same number of seconds, whether the movement was made by the stem or the sternpost.

"It appears natural to conclude from these experiments, that the form of the bows of ships does not much influence the resistance which they experience in passing through the water. Several objections may, however, be made to that conclusion.

"First, the experiments made by M. Romme might appear to be wanting in precision, because the duration of each observation being sufficiently short, a small error of the measured time gives a large enough error in the resistance. In the smallest velocities, the bodies ran through their space in 27″ only, and in the greatest velocities, they employed only 15″ in running through it,—and even from 13″ to 14″, when the bodies were at their least draught of water. It is certain that the smallest errors committed in these observations might greatly affect the results; and it might have been desired that M. Romme should have made his experiments with the smallest velocities, or that he should have remedied the defect of the short duration of the observations by some proper means. Nevertheless, as his experiments were often repeated, and as their mean result always gave equal resistances, as besides, experiments have been made on bodies of very different form, and as we limit ourselves to infer the equality of resistance between bodies such as our ships, which differ little from each other, it appears right to say that the experiments of M. Romme have proved the proposition which he had advanced.

"It may be again objected, that it is possible the two figures which M. Romme has compared, have experienced the same resistance, only because they were equally defective, the one being too sharp and the other too obtuse; and that, perhaps, two other figures, less dissimilar, would have experienced resistances different from each other. But it must be confessed that this would be the effect of a rather extraordinary chance, the more so, as the experiments were made at three different draughts of water, the first at nineteen inches, the second at sixteen inches, and the third at fourteen inches, and, consequently, the comparison has been really established between three different sorts of bodies. Besides, it must also be said that the same chance has taken place in an experiment reported in the mémoires of the academy in the year 1767, page 502, where it is seen that a prismatic body, terminated at one end by two plains and at the other by two curves, experienced the same resistance, whether it was moved by one end, or by the other; finally, there is found in the work of Chapman, the celebrated Swedish constructor, an experiment which gives the same result. A solid of revolution, conical at one end, and parabolic at the other, experienced the same resistance, by whichever end it was moved.

"The last objection that can be made to M. Romme, and which appears the most important, is drawn from experiments made on a large scale; I would say, of those which are daily experienced at sea. In truth, it appears to be generally recognized, that the simple transport of weights, from one end of the ship to the other, is sometimes enough to produce a sensible difference in her velocity. Now, this transport does nothing else than increase or diminish the draught of water forward or abaft. The form of the midship-section remains the same. How can it be, that the small variation which the figure of the bow then experiences, should produce a marked effect on the velocity, and that differences as considerable as those of the two models compared by M. Romme, should produce none? We confess that it is not possible to us to reconcile these two things. It may perhaps be replied in favour of M. Romme, that none of the theories that have been conceived on the resistance of fluids, account for the fact that has just been cited, and that in calculating, according to these theories, the change of resistance which the ship experiences when the inclination by the bow or the stern is increased only by some inches, extremely small differences are always found, which would make it believed that the difference in the trim of a ship is perhaps attributed to what results from every other cause; as, for example, that by the new inclination of the masts, the sails take a different position in relation to the wind, and are trimmed more or less advantageously, or perhaps that the fore and after sails, being then better balanced, and being more in equilibrium with the resultant of the shock of the water on the body, there is no more need to keep the ship in her direction by the action of the rudder, which always retards the speed. We should not dare to say that these are the true reasons of the change in ships' velocity, caused by the difference of their trim, but we should be very much inclined to believe it.

"We conclude, from the examination that we have just made of the experiments of M. Romme, that, if it is not exactly true that the form of the bows of ships does not much affect the resistance which they experience by the shock of the water, it is at least very probable that the bows may vary a good deal, the midship section remaining always the same, without the resistance being perceptibly altered. Great obligations are due to M. Romme for having proved, by experiment, this truth,—which is of the greatest importance to the art of construction, and which may contribute much to its perfection."

In comparing the velocity of a rigid body moving in a resisting medium with the force of resistance to which the body is subject, one element of considerable importance has been omitted by writers on the theory of resistances; the element here alluded to is the inertia of the mass of matter moved.

A little consideration will suffice to show, that the *inertia* consists of two distinct parts; the first is the inertia of the rigid mass moved, and is evidently a constant quantity for the motion of the same rigid body; the second is the inertia of the mass of fluid medium put in motion by the rigid mass moved: this inertia is variable; it increases as the velocity of the rigid mass increases, and diminishes as it diminishes, by a law which may be conveniently expressed by $f(v)$, where v represents the velocity of the rigid mass moving in the resisting medium.

Hence the whole inertia of the mass moved may be represented by—

$$\frac{W}{g} + f(v) \quad . \quad . \quad 1.$$

Where, W = weight of rigid mass,
g = accelerating force of gravity.

If we suppose the *statical* resistance to be represented by $F(v)$ when the rigid body is moving with a velocity v, and F' to represent the constant force applied to the rigid mass to move it with a velocity v, we shall have, for the motive force which acts upon the rigid body, the expression—

$$F' - F(v) \quad . \quad . \quad 2.$$

The accelerating force is always equal to the motive force divided by the inertia of the mass moved.

Therefore $$\frac{d^2s}{dt^2} = g.\frac{F' - F(v)}{W + gf(v)} \quad . \quad . \quad . \quad 3:$$

where s represents the space through which the rigid body moves, to acquire a velocity v in the time t.

If we take into account the friction of the fluid medium through which the rigid mass moves, the expression (2) will become

$$F' - F(v) - R \quad . \quad . \quad 4:$$

where R depends upon the surface of the rigid mass moving through the medium.

Then equation (3) becomes—

$$\frac{d^2s}{dt^2} = g.\frac{F' - F(v) - R}{W + gf(v)} \quad . \quad . \quad 5.$$

Explanation of $F(v)$.

$F(v)$ is the resultant of the fluid's pressure on the surface of the rigid body, in the direction of its motion with a velocity v.

When the velocity is zero, the function $F(v)$ must necessarily vanish, in consequence of the fluid pressure being equal in opposite directions throughout the whole extent of the surface of the rigid body placed in the fluid medium.

When the rigid body is in motion, the fluid pressure at every point throughout its surface must be resolved in the direction of its motion, and these resolved forces must be computed, generally, by means of the integral calculus; their sum will represent the value of $F(v)$.

Let p be the pressure, in the direction of a normal, at the point P on the surface of the rigid mass.

And x, y, z, the rectangular coordinates of the point P referred to a fixed point in the interior of the body; x is measured in the direction of the body's motion, y is measured horizontally, and z vertically. And let α, β, γ, be the angles which the normal makes with the axes x, y, and z, respectively, we shall have p cos. α, p cos. β, p cos γ, for the resolved forces in the directions of x, y, and z respectively—

$$\therefore F(v) = \Sigma\,(p \text{ cos. } \alpha);$$

where Σ refers to every point on the surface, and Σ (p cos. β) will in all cases be equal to nothing.

Σ (p cos. γ) will add to or subtract from the weight of the body, and thereby affect the value of $F(v)$.

Both p, α, and γ will vary with every point on the surface,—p depending on the velocity of the surface, and α, γ on its form.

Explanation of $f(v)$.

The quantity $f(v)$ depends partly on the number of particles of fluid moving with the same velocity as the rigid body, and partly on the number of particles moving with a variable velocity.

In the force R is included the amount of force necessary to separate the particles of fluid through which the rigid body passes; this amount is very small in most liquids, and large in rigid masses.*

In 1796 Mr. Atwood published a paper, in the Transactions of the Royal Society, on the stability of ships and other floating bodies. The paper is written with great ability, and with a comprehensive knowledge of the mathematics, and the application to mechanics and hydrostatics. This knowledge enabled him to develop successfully the theory of statical stability. It is intended to give here such extracts from this valuable paper as will make the reader acquainted with its contents. In the first place he gives a complete exposition of the three different positions in which a body floats permanently.† He also points out the error into which Bouguer, Euler, Chapman, and other writers on the subject, had fallen, in supposing that the inclination of ships from their quiescent position is evanescent, or, in a practical sense, very small. The force of his remarks on this subject has been generally acknowledged.

He next proceeds to establish the following proposition. AHB (Fig. 9) is the section of a symmetrical solid body, floating in a fluid whose specific gravity is a given quantity; $A B$ is the water-line before the vessel has been deflected by the force of the wind and waves, or other causes; $A' B$ is the water-line after it has been deflected through the angle $A\ O\ A'$. $S\ H$ and $S\ H'$ are drawn perpendicular to $A B$ and $A' B'$ respectively, the first through the centre of gravity of the vessel, and the second through the centre of gravity of the part $A' H' B'$ immersed. C and C' are the centres of gravity of $A\ O\ A'$ and $B\ O\ B'$; $C D$ and $C' D'$ are perpendicular to $A' B'$. $V =$ the volume of $A H B$, and $V' =$ the volume of $A'\ O\ A = B\ O\ B'$. He then showed that

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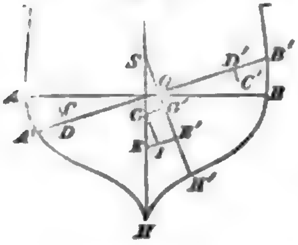
* The conclusion of this article has been supplied by the favour of Mr. Robert Rawson, from a paper on the Resistances of Fluids, which he is preparing for publication.

† This is by no means peculiar to a *floating* body; the same states of equilibrium, viz., stable, instable, and indifferent, belong equally to a solid body subject to the action of external forces.

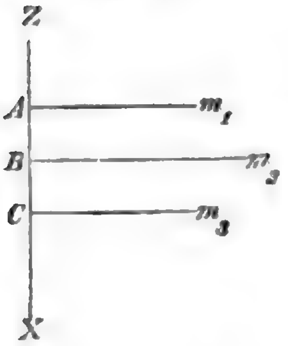
Fig. 9.



$$G G' = \frac{D D' V'}{V} - G E. \sin. A O A';$$

where $G\ G'$ is parallel to $A' B'$, and G the centre of gravity of the body.

Fig. 10.



The demonstration of this problem depends upon the following property of the centre of gravity of a system of material points. Let m_1, m_2, m_3, &c. &c., (fig. 10) be a system of material points; draw $m_1\ A, m_2\ B, m_3\ C$, &c. &c., perpendicular to $Z X$; call these distances r_1, r_2, r_3, &c. &c.: and their common centre of gravity from $A C$ denote by G.

$$\text{Then } G = \frac{r_1 m_1 + r_2 m_2 + r_3 m_3 + \&c.}{m_1 + m_2 + m_3 + \&c.} \quad . \quad (1).$$

Now let m_1 be removed to r'_1 distance from $A C$; then if G' is their common centre of gravity, we shall have by (1)

$$G' = \frac{r'_1 m_1 + r_2 m_2 + r_3 m_3 + \&c.}{m_1 + m_2 + m_3 + \&c.} \text{ or } G' - G = \frac{(r'_1 - r_1) m}{m_1 + m_2 + m_3}:$$

that is, the distance through which the centre of gravity has been moved in the direction in which m_1 has been moved is equal to $\frac{m_1}{m_1 + m_2 + m_3}$ times the distance through which m has been moved. This principle is readily applied to the determination of Mr. Atwood's problem.

E is the centre of gravity of $A H B$. By the inclination, the centre of gravity c of the volume $A\ O\ A'$, has been removed from c to c', a distance $D\ D'$ in the direction $A' B'$. Therefore by the property just demonstrated we have

$E E' = \frac{D D'. V'}{V}$; and by trigonometry we have

$E I = G E. \sin. E G I = G E. \sin. A O A'$; $\therefore G G' = \frac{D D'. V'}{V} - G E. \sin. A O A'$.

If W is the weight of the vessel, then $W. G G'$ is the moment of the force which tends to restore the equilibrium of the body, after it has been deflected through the angle $A\ O\ A'$: hence the importance of calculating this value in computing the stability of vessels.

Atwood has made the line $G\ G'$ the measure of a vessel's stability. He proceeds next, to determine $G\,G'$ by means of the conditions necessary for the three kinds of equilibrium. Thus, if $\frac{D\,D'\,V'}{V} > G\,E.\ \sin.\ A\,O\,A'$, we shall have an equilibrium of stability; if $\frac{D\,D'\,V'}{V} < G\,E.\ \sin.\ A\,O\,A'$, we shall have an equilibrium of instability; and if $\frac{D\,D'\,V'}{V} = G\,E.\sin.A\,O\,A'$, we shall have an equilibrium of indifference. By supposing the angle $A'\,O\,A$ to become evanescent, or very small, he obtains a formula for $\frac{D\,D'\,V}{V}$ in all solid floating bodies, well adapted for the computation of their stabilities.

If we suppose z to be measured along the intersection of the planes $A\,B$ and $A'\,B'$, since the volume $A'\,O\,A$ is evanescent, and gives $A'\,O = O\,B'$, we shall have $\frac{1}{2}\int A'\,O^2.\sin.A'\,O\,A.\,d\,z = V'$

and $D\,D' = \frac{4\int A'\,O^3.\ \sin.\,A'\,O\,A.\,d\,z}{3\int A'\,O^2.\ \sin.\,A'\,O\,A.\,d\,z}$

Then $G\,G' = \frac{2\int A'\,O^3.\sin.\,A'\,O\,A.\,d\,z}{3\,V} - G\,E.\sin.\,A'\,O\,A$, which is a general expression for ascertaining whether a solid, when placed on the surface of a fluid, will float permanently or overset. The sine of the angle $A'\,O\,A$ being evanescent, we may use the arc instead of the sine; then the above formula will become $G\,G' = \frac{2}{3}\frac{\overline{A'\,O\,A}}{V}\left\{\int A'\,O^3\,d\,z - \frac{3\,V.\,G\,E}{2}\right\}$.

These formulæ are applied in determining the stability of the solids whose vertical sections form an oblong parallelopiped, a cylinder, or a parabolic conoid. In all these cases the figures are subjected to the computation of all their various forms. In the next place we have a further discussion on the formula $G\,G' = \frac{2}{3}\frac{\overline{A'\,O\,A}}{V}\left\{\int A'\,O^3\,d\,z - \frac{3\,V.\,G\,E}{2}\right\}$; and also a notice of the method used in practice to approximate to the areas of curvilinear figures, stated by Sterling, Simpson, and others. After giving an example, comparing Sterling's method with Chapman's, which is founded on the properties of the parabola, he observes, that the same method by which the areas of curves are found by approximation, may be applied with equal exactness to determine the solid contents of space and the position of the centre of gravity.

Reference is then made to some important facts regarding stability, that are mentioned by M. Romme in "L'Art de la Marine." The ships whose deficient stability was the subject of inquiry were *Le Scipion*, *L'Hercule*, and *Le Pluton*. Atwood indicates with great clearness the various causes of instability in vessels, and observes that the force of stability is to be considered as operating on the ship, after the force by which it has been inclined ceases, to restore the vessel to its upright position; the ship, being continually impelled by the force of stability, revolves about a horizontal axis, passing through the centre of gravity, with an increasing velocity, till it arrives at its upright position, and afterwards with a velocity continually retarded till it arrives at the greatest inclination on the other side. This rolling of the ship, with the alternate acceleration and retardation of the angular velocity, will evidently depend on the force by which the angular motion is generated; that is, on the force of stability, and its variation corresponding to the several angular distances of the vessel from its upright position. From this cause arises one of the practical difficulties* in naval architecture; that is, to give a vessel a sufficient degree of stability, and at the same time to avoid the inconveniences which proceed from the too rapid increase and decrease of the angular velocity in rolling. It is certain that the variation in the force of stability depends principally on the shape given to the sides of the vessel, which admit of being so constructed that the force shall increase either slowly or rapidly to its limit. Some useful observations are made on the rolling of ships, with reference to the writings of Bouguer, Bernoulli, and Euler. Bouguer deemed the rolling of ships to be analogous to the vibration of a pendulum, and he proposed to find the length of a pendulum which should be isochronal with the oscillations of vessels. On this, Atwood observes, that this problem seems to imply both, that the pendulum sought, and the vessel itself, shall vibrate in arcs that are extremely small; for otherwise the analogy would fail altogether. He further states that no oscillating body can describe arcs of unequal lengths in equal times, unless it is impelled by forces which are in the direct ratio of the distances from the quiescent point; and, therefore, the oscillations of a vessel vibrating in different finite angles are evidently not isochronal with each other, since the force of stability varies in a proportion so different from that of the distances from quiescence; nor can they be isochronal with any pendulum, unless the arcs of vibration are of evanescent magnitude, in which case the force of stability, being in the direct proportion of the angles of inclination from the upright, has the effect of producing an equality in the times of oscillation. To ascertain a pendulum vibrating in small arcs which is isochronal to the oscillations of a vessel, under these restrictions, is a problem which may be solved with sufficient exactness; but unless the limitation that has been mentioned should be specified, the question is without the necessary conditions. M. Bouguer, in the chapter entitled *"que les oscillations sont isochrones,"* does not expressly mention this limitation; but it is probable that he conceived it to be implied. In the remarks on the rolling of vessels, it appears that Atwood wishes it to be understood that the water's resistance has not been considered, which must necessarily have some influence in retarding the oscillations of the vessel, and more in the larger than in the smaller arcs. It must, however, be observed, that the resistance to the rolling of vessels is of a very different kind from that which is opposed to their progress through the water; as, in this case, a volume of the fluid proportional to the vessel's bulk and velocity, is entirely displaced during its motion; whereas, in the rolling of ships, a far less quantity of water suffers a change of place by the ship's oscillations, which are therefore the less retarded on this account.

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* This difficulty has been entirely overcome by an admirable formula discovered by Professor Moseley.

The paper is concluded by a brief statement and exposition of the resistances of fluids. He states that the theory of Bouguer, Euler, and others, which is founded on the resistances being in the duplicate ratio of the velocities, is not sufficient to account for all the complicated laws of bodies moving in fluids. The truth of this assertion appears to depend on the investigations and experiments of the Society for the improvement of Naval Architecture, and published by their order. These experiments show that the resistance of friction on a smooth body moving in water upon a surface of 258 square feet was equal to a weight of 90 pounds, the velocity being eight feet per second; and also that the resistance is not expressible by less than three terms of the velocity; that is, if z denotes the resistance, and v the velocity, then we have $z = av^3 + bv^2 + cv$; in which a, b, and c are constant quantities to be found by experiment.

Mr. Atwood's second paper, entitled "A Disquisition on the Stability of Ships," was published in the "Transactions of the Royal Society," March 8, 1798.

After stating the absolute necessity of attending to the stability of vessels, he proceeds to illustrate the application of abstract science to their construction and management, by referring to the success which had attended the labours of Newton, in his explanation and development of natural phenomena.

"The theory of mechanics having been greatly extended and successfully employed by Sir Isaac Newton, in the investigation of causes requiring the most profound research, would naturally be resorted to for a solution of many difficulties that occur in the theory of naval architecture, which could not be obtained from any other mode of considering the subject." He goes on to distinguish the principles of construction, "which are founded upon truth and right practice, from others which are the offspring of vague and capricious opinion, misinterpretation of facts, and unfounded conjecture, by which phenomena arising in the practice of navigation are often attributed to causes entirely different from those by which they are really governed."

"Although all results deduced by strict geometrical inference from the laws of motion are found, by actual experience, to be perfectly consistent with matter of fact, when subjected to the most decisive trials, yet in the application of these laws to the subject in question, difficulties often occur, either from the obscure nature of the condition, or the intricate analytical operations arising from them, which render it impracticable to obtain a solution; or, if a result is obtained, it is expressed in terms so involved and complicated as to become in a manner useless as to any practicable purpose." He justly observes, with "respect to the theory of vessels, it would be giving that term too narrowed a meaning to consider it as derived solely from the laws of mechanics; every notion or opinion which may be applied to explain satisfactorily the phenomena depending on a vessel's construction and qualities, so as to infer the consequences of given conditions, independently of actual trial, whether it originated from experience alone, or from investigation founded on the laws of motion, is to be regarded as forming a part of this theory, in which a constant reference to practice is so essentially necessary; for although many principles are deducible from the laws of mechanics, which it is probable that no species of experiment, or series of observation, however long continued, would discover, yet there are others, no less important, which have been practically determined with sufficient exactness, the investigation of which it is scarcely possible to infer from the laws of motion; the complicated and ill-defined nature of the conditions in particular instances, rendering analytical operations founded on them liable to uncertainty. Since the practice of naval architecture depends so materially on the knowledge of the causes which influence the motion of vessels at sea, much benefit may probably be derived from the extension of well-founded principles, both by attentive observation of the qualities of vessels, compared with their construction, as well as by investigation of the effects arising from particular modes of construction, depending on the laws of statics and mechanics, whenever the conditions admit of inferring principles which are clear and satisfactory, and easily applicable to practice."

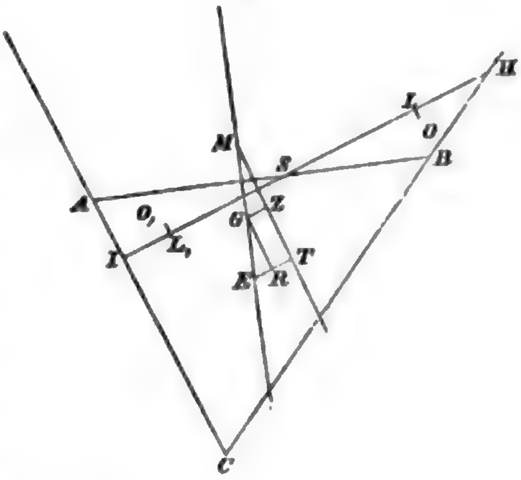
We are again introduced to the investigation of the formula of stability given in the first paper, "to avoid the necessity of future references, as well as for the purpose of stating more distinctly the observations which follow it."

Many pages are appropriated to the calculation of the line GZ, or the perpendicular distance from the centre of gravity of the vessel to the vertical line passing through the centre of effort in vessels of various sectional forms. Although many of these calculations are not difficult, yet they are attended with considerable labour, and it is quite possible, from the advances which have been made in pure mathematics since the time of Atwood, that some of these calculations may admit of simplification; but notwithstanding this, the mathematical reader will find there the display of a sound and vigorous judgment on questions of pure and mixed science.

Thirteen cases are given, in each of which the value of the line above mentioned is ascertained and applied to calculate the moment of stability, or the force required, when applied at a certain height from the centre of gravity of the vessel, just to balance the force with which the vessel endeavours to regain its position, after it has been deflected through a given angle.

We shall endeavour to illustrate the general principle investigated in this paper, by an example, when the section of the floating body is a triangle. Let ABC (fig. 11) be a section of the floating body; AB the water-line at rest; G its centre of gravity; and E the centre of gravity of the part immersed. Let the floating body be inclined so that IH is the water-line. Draw MT through the centre of gravity of the part ICH immersed, perpendicular to IH, and ET, GZ parallel to IH, and GR parallel to MT. Put $\angle ACB = C$, $\angle CAB = A$, and $\angle ABC = B$. $\angle BSH = \theta$; which is equal to $\angle EMT$ or EGR. o and $o_{,}$ are the centres of gravity of the triangles SBH and ASI.

Fig. 11.



$$2\,\triangle SHB = SH.\,SB.\sin.\theta$$

$$2\,\triangle ABC = AB.\,CB.\sin.B.$$

$$\therefore \frac{\triangle SHB}{\triangle ABC} = \frac{SH.\,SB.\sin.\theta}{AB.\,BC.\sin.B}. \quad . \quad . \quad . \quad . \qquad (1).$$

But, since the sides of triangles are proportional to the sines of their opposite angles, we have

$$\frac{SB}{SH} = \frac{\sin.(B-\theta)}{\sin.B}$$

$\therefore SB.\,SH = SH^2.\dfrac{\sin.(B-\theta)}{\sin.B}$. By substituting this in equation (1), we have

$$\frac{\triangle SHB}{\triangle ABC} = \frac{SH^2}{AB.BC}.\frac{\sin.\theta.\sin.(B-\theta)}{\sin.^2 B}. \quad . \qquad (2)$$

Next, let the value of SH be found.

Since $\triangle AIS = \triangle SHB$, we have by Euclid (vi., 15)

$$\frac{AS}{SB} = \frac{SH}{SI} \quad . \quad . \quad . \quad . \quad . \quad . \qquad (3)$$

By trigonometry, we have

$$\frac{SH}{SB} = \frac{\sin.B}{\sin.(B-\theta)}; \text{ and } \frac{SI}{AS} = \frac{\sin.A}{\sin.(A+\theta)}.$$

From these equations we have $\frac{SH}{SB}.\frac{AS}{SI} = \frac{\sin. B. \sin. (A+\theta)}{\sin. A. \sin. (B-\theta)}$.

From (3) we have $\frac{AS^2}{BS^2} = \frac{SH.AS}{SB.\ SI}$;

$$\therefore \frac{AS}{BS} = \sqrt{\frac{\sin. B. \sin\ (A+\theta)}{\sin. A. \sin. (B-\theta)}} = n-1$$

and $\frac{AB}{BS} = n \therefore BS = \frac{AB}{n}$

But $SH^2 = BS^2. \frac{\sin.^2 B}{\sin.^2 (B-\theta)} = \frac{AB^2. \sin.^2 B}{n^2. \sin.^2 (B-\theta)}$.

By substituting this value in (2), we have

$$\frac{\triangle\ SHB}{\triangle\ ABC} = \frac{AB. \sin\ \theta}{n^2\, BC. \sin. (B-\theta)} = \frac{\sin. \theta. \sin. C}{n^2 \sin. A. \sin. (B-\theta)}. \qquad (4).$$

It will not be difficult to see that $\frac{SH}{SI} = n-1$; $\therefore \frac{IH}{SI} = n$; or $IH = n.SI = n.AS. \frac{\sin. A}{\sin. (A+\theta)}$.

But $AS = (n-1).BS = \frac{n-1}{n}.AB$;

$$\therefore IH = \frac{(n-1).\ AB. \sin. A}{\sin. (A+\theta)} = AB\sqrt{\frac{\sin. A. \sin. B}{\sin. (B-\theta). \sin. (A+\theta)}}.$$

And $LL_{,} = \frac{IH}{3} + \frac{AB. \cos. \theta}{3}$

$$= \frac{(n-1)\ AB. \sin. A}{3 \sin. (A+\theta)} + \frac{AB. \cos. \theta}{3}$$

$$= \frac{AB}{3}\left\{\frac{(n-1) \sin. A}{\sin. (A+\theta)} + \cos. \theta\right\}$$

$$= \frac{AB}{3}\left\{\frac{\sqrt{\sin. A. \sin. B}}{\sqrt{\sin. (A+\theta). \sin. (B-\theta)}} + \cos. \theta\right\},$$

by restoring the value of $(n-1)$.

By Atwood's formula we have

$$ET = LL_{,} \times \frac{\triangle\, SHB}{\triangle\, ABC}$$

$$= \frac{AB. \sin. \theta. \sin. C}{3n^3 \sin. A. \sin. (B-\theta)}\left\{\left(\frac{\sin. A. \sin. B}{\sin. (A+\theta). \sin. (B-\theta)}\right)^{\frac{1}{2}} + \cos. \theta\right\}$$

$$\therefore GZ = \frac{AB. \sin. \theta. \sin. C}{3n^2. \sin. A. \sin. (B-\theta)}\left\{\sqrt{\frac{\sin. A. \sin. B}{\sin. (A+\theta). \sin. (B-\theta)}} + \cos. \theta\right\} - d \sin. \theta,$$

where $n = 1 + \frac{\sqrt{\sin. B. \sin. (A+\theta)}}{\sqrt{\sin. A. \sin. (B-\theta)}}$.

Cor. (1). If $A = B$, we have $C + 2B = 180$, or $C = 180 - 2B \therefore \sin. C = \sin. 2B$; consequently

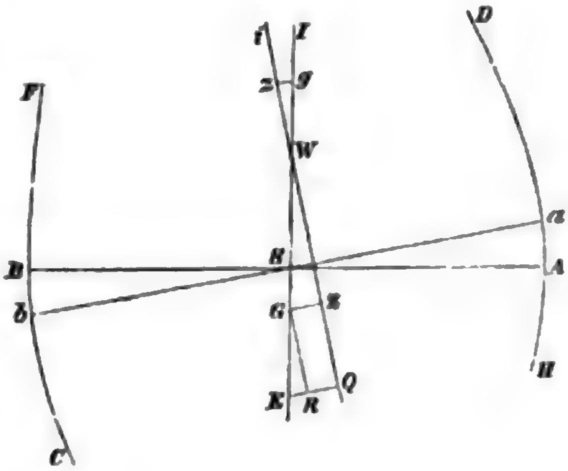
$$GZ = \frac{2 \sin. \theta. AB}{3n^2. \sin. (B-\theta)}.\left(\frac{\sin. B}{\sqrt{\sin. (B+\theta). \sin. (B-\theta)}} + \cos. \theta\right) - d \sin. \theta;$$

where $n = 1 + \frac{\sqrt{\sin. (B+\theta)}}{\sqrt{\sin. (B-\theta)}}$

This investigation is introduced for the help of those who may find it more convenient to arrive at the conclusion which Mr. Atwood has reached, by a shorter path. It is no disparagement of him to say that a principle is susceptible of more concise investigation now, than it received at his hands; for half a century has witnessed important changes in the manner of treating many sorts of questions to which mathematics are applied.

We are now conducted to the celebrated theory of Bouguer, respecting the metacentre, about which Atwood makes the following observations:—"It may be proper to remark, that the metacentric curve described by Bouguer and M. Clairbois, and applied to the preceding cases, does not appear to have any relation to the stability of vessels, except in the single point where the curve intersects the vertical axis, and therefore can be applicable only in the case when the angle of the vessel's inclination from the upright is evanescent. Let *F B C*, *D A H* (fig. 12) represent the sides of a vessel, *B A* coinciding with the water's surface when the vessel floats upright; bisect *A B* in *S*, and draw *I S E* perpendicular to *B A*. Let *E* be the centre of gravity of the volume immersed. Suppose the vessel to be inclined through a very small angle *A S a*, so that the water's surface shall now coincide with *b a*; and let the centre of gravity of the volume immersed be *Q*. Through *Q* draw the line *Q W z* perpendicular to *b a*, intersecting the line *I E* in the point *W*. This point is called by M. Bouguer the metacentre. One of the principal properties of this point is, that whenever the centre of gravity of the vessel is situated beneath it, anywhere in the line *W E*, (suppose at *G*,) the vessel will float permanently with the line *I E* vertical; but that, if the centre of gravity is placed above the metacentre, (suppose at *g*,) the vessel will overset, from that position; for drawing *G Z*, *g z*, perpendicular to *Q z*, if the vessel should be inclined through a small angle *A S a*, so as to immerse a portion of the side *A a*, the force of pressure acting in the direction of the line *Q Z*, to turn the vessel round an axis passing horizontally through *G*, will elevate the parts adjacent to *A*, so as to restore the upright position; whereas if the centre of gravity should be placed above the metacentre, suppose at *g*, the same force of the fluid's pressure, by turning the vessel round an axis passing through *g*, must immerse further the portion of the side *A a*; and this immersion, being continued, will cause the vessel

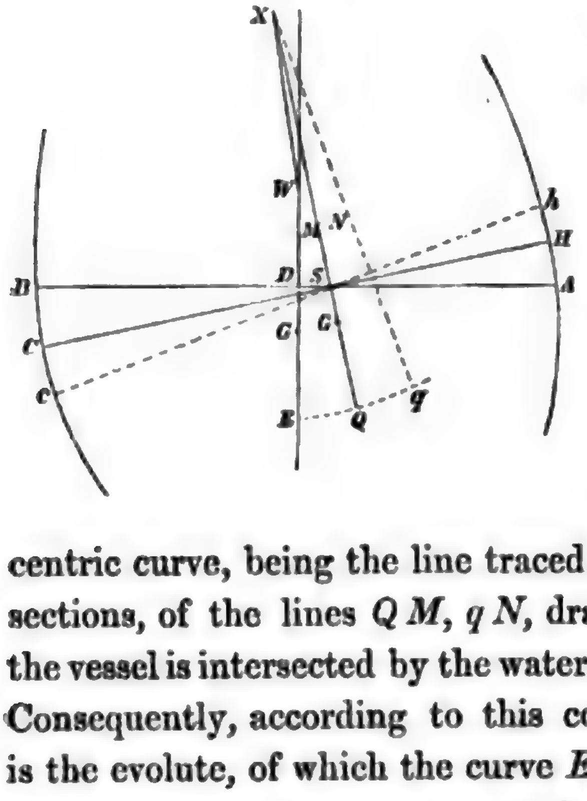
Fig. 12.



to overset. Another property of this point has been demonstrated by M. Euler and other authors, which is that when the angles of a vessel's inclination are evanescent, or very small, the effect of stability to restore the vessel to the upright position, will be as the sine of the angle of inclination *G W Z* and the line *W G* jointly; at the same small angles of inclination, the stability of different vessels will be in proportion to the line *W G*, or distances of the metacentre above the centre of gravity.

"Let the curve *E Q q* (fig. 13) represent the line traced by the successive centres of gravity of the immersed volumes, while the vessel is inclined from the upright through any angle *A S H*. M. Bouguer demonstrates that a tangent to this curve in any point *Q*, will be parallel to the water's surface *C H*, corresponding to that point; if, therefore, through any two adjacent points *Q* and *q*, in the curve *E Q q*, the lines *Q M*, *q N*, are drawn perpendicular to the lines *C H*, *c h*, respectively, the intersection of those lines in the point *X* will be the centre of curvature, and *X Q*, *X q*, will be the radii of a circle which has the same curvature with the curve *E Q* in the point *Q*. For the same reasons, the line *W E* (fig. 13) is the radius of a circle which has the same curvature with the curve *E Q* in the point *E*. The point *W* has been denominated the metacentre corresponding to the upright position of the vessel, when the line *W G E* is perpendicular to the water's surface. M. Bouguer denominates the point *X* the metacentre corresponding to the position when the vessel has been inclined from the upright through the angle *A S H*; and the curve *W X* is termed the metacentric curve, being the line traced by the successive metacentres, or intersections, of the lines *Q M*, *q N*, drawn perpendicular to the lines in which the vessel is intersected by the water's surface, while it is gradually inclined. Consequently, according to this construction, the metacentric curve *W X* is the evolute, of which the curve *E Q q* is the involute." Atwood goes on to observe that the properties of the metacentric curve have to be investigated by geometrical reasoning, and on this ground are liable to neither ambiguity nor error; but it does not appear either in the works of M. Bouguer, or M. Clairbois, or in some of more recent date, on what grounds these properties are applied to measure the stability of vessels, or to estimate their security from oversetting, when much inclined from the upright.

Fig. 13.



Though the discovery of the metacentre could not be made by merely practical men, yet it was a thing which lay in the line that a mathematician would pursue in investigating this subject; and the importance of this point is such, that he would not fail of pointing out its position on having determined it. But, *in the question of stability,* it is not obvious that the *metacentric curve* is of any value. The speculations of Bouguer were conducted apart from the practice of naval architecture, and their results were such as the practical architect might have sought in vain. The principles upon which the moment of force to keep a floating body deflected at any given angle can be calculated, were well known before Bouguer wrote; but the metacentre, which he was the first to notice, serves admirably, by its position in relation to the centre of gravity, to mark the different conditions of stability—as stable, instable, and indifferent; so far the special notice and naming of the point are of great importance.

Several pages are devoted to a description of the rules for approximating to the area of plane curves, given by Newton, Sterling, and Simpson. The rule given by the last-named celebrated author has been used by the most eminent writers on the continent, and a demonstration of it is to be found in Francour's Mathematics: such notice has seldom been taken of any English mathematician. Atwood concludes this very interesting paper with an application of the principles which he has developed in it to a few numerical examples, with the nature of which all students of naval architecture should be acquainted.

The value of Atwood's papers has been established in England beyond all dispute. The practice of naval architecture for half a century is an eminent proof of the correctness of the result at which he arrived on theoretical considerations. Those who appreciate his works ought, however, to know that the two conditions on which a ship's stability depends, and the principle on which it is measured, had been clearly stated by Bernoulli and Euler,* whose works it appears Atwood had read, since he noticed their defects. Thus the merit of Atwood does not consist so much in the discovery of principles, as in taking up principles already indicated, demonstrating their legitimate consequences, and showing their application to practice.

Neither Bernoulli, Euler, nor Atwood has given any attention to the effect which is produced on the amplitude of a vessel by the force, re-

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See "Principes Hydrostatiques et Mécaniques, sur la question proposée pour la seconde fois par l'Académie Royale des Sciences: 'Quelle est la meilleure maniere de diminuer le Roulis et le Tangage d'un Navire, sans qu'il perde sensiblement par cette diminution aucune des bonnes qualités que sa construction doit lui donner.' Par M. Daniel Bernoulli; Paris, 1757;" also, "A Complete Theory of the Construction and Properties of Vessels," &c., by Leonard Euler, translated by Henry Watson, Esq., Book i., Chap. 4; London, 1790.

quired to keep it at a given angle, being suddenly and consecutively applied from a state of rest to the extremity of the amplitude of the oscillation. Atwood's formula shows only the amount of force required to *preserve* a vessel in an inclined position, without regarding the effect of the accumulation of impulsive force on the vessel. In consequence of this omission in theory, naval architects have found it difficult to determine precisely what elements most affect the rolling motion of a vessel.

This desideratum has been lately supplied by Professor Moseley,* who has formed an elegant theorem for determining the amount of force which, acting successively in obedience to any law, is necessary to incline a vessel from an upright position to any given angle of inclination.

Let H and H_1 be the perpendicular distances, respectively, from the centre of gravity of a vessel to the plane of flotation, when the vessel is at rest, and when it is inclined through a given angle θ; and let h and h_1 be the perpendicular distances, respectively, from the centre of gravity of the part immersed to the plane of flotation, when the vessel is at rest, and when it is inclined through the angle θ.

Put $W =$ the weight of the vessel:

Then if U is the number of units of work necessary to incline the vessel from an upright position to an angle θ, we shall generally have

$$U = W\left\{(H - H_1) \sim (h - h_1)\right\}$$

The discovery of this formula is one of the greatest steps that has been taken in the theory of naval architecture since the time of Bernoulli. The formula has been verified in a great number of experiments, made at Portsmouth dock-yard, in accordance with an Admiralty order, under the direction of the author and Mr. Rawson. In conducting these experiments they have discovered the important fact, that the angle of amplitude obtained by the impulse of a gust of wind, or by other forces, acting suddenly and constantly, is about twice as great as the angle at which the same force would keep the vessel at rest at any inclination. The formula is of easy application to practice.

This introduction shows how the theory of naval architecture is identified with the laws of fluid matter, and is thus associated with one of the most difficult branches of natural philosophy. Being thus dependent on those laws, and unable to advance beyond the point of their development, great labours have been undertaken to enlarge the boundary of science, for the improvement of naval architecture; the success has, however, always been small in relation to the efforts. Before the time of Archimedes, the mere facts of the buoyancy of some bodies in water were known as well as they have been known since; but he discovered the law which determines these facts, and wrote a treatise on the subject. It was long before the next important step in hydrostatics was taken; it remained for Stevinus to determine that the pressure of fluids is in proportion to their depth. A third discovery of the properties of a fluid was made by Pascal—that it exerts an equal pressure in all directions: this last principle includes the two preceding.

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* On Dynamical Stability, and on the Oscillations of Floating Bodies, by the Rev. Henry Moseley, M.A., F.R.S., in the Philosophical Transactions, Part 2, for 1850.

These are the only fundamental principles of fluids that have been yet determined. The knowledge of these, however, meets the necessity of the naval architect, with reference to the buoyancy and stability of ships; and numerous experiments have realised an approximation to the law which determines the resistance of fluids; but the exact law has not been traced. In the "Examen Maritime," by Don George Juan, the subject is treated at considerable length; but as some of the fundamental principles are assumed rather than demonstrated, and as experiment has shown that the principles he assumed are wanting in exactness, even supposing his application of them to be true; and also, as the manner proposed by him to determine the resistance opposed to a ship in passing through the water, is deficient in the clearness necessary to practice, this branch of the science of naval architecture has not been advanced by that highly talented author.

In looking at the progress of naval architecture, we see that theory has been scarcely an object of study in England; and we are forced to the inference that an adequate cause must have existed for the prevailing indifference to science. The cause has prevailed, and continues to exist; for, to a great extent, the effect still exists. Atwood, whose papers on the stability of floating bodies have been text-books for naval architects for half a century, produced no new ideas on the subject: it is clear that he obtained his principles from foreign authors. No other work on naval architecture in England has professed to exhibit new truth or to extend the science: this object has never been made *national;* on the contrary, the policy of government has almost invariably had a tendency to discountenance and repress science. From the latter part of the seventeenth century, the usage of the service was to determine the construction of ships by the regulations of office. This necessarily excluded science, and discouraged scientific education. The course of experience from the earliest date of official establishments for the dimensions of ships, clearly shows this effect; there were education, great talent, and improvement before: Mr. Pett and Sir Anthony Deane adorned their profession; but, after their time, the general qualifications of ship-builders appear simply to have met the requirements of the service as practical men. This state of things continued till the beginning of the present century, when the Board of Revision recommended, amongst various improvements, a sound mathematical education for shipwright officers; and until that recommendation was carried into effect, if all the rays of science in the country had been concentrated upon naval architecture, there would have been no power in the service to receive and use the light. The rays were begun to be collected to a focus by means of the late School of Naval Architecture; but, unfortunately, this was not appreciated by the Admiralty and Navy Boards; the government having omitted any attempt to cultivate science in the higher departments. The School of Naval Architecture was suppressed, and almost all who had been educated in it, and who remained in the service, were for a considerable length of time kept in subordinate situations, in which no opportunity was allowed them to prove the value of the education they had received. This opportunity was at length given by the board of Admiralty, under the earl of Haddington, and that board and the present have shown more regard to superior qualifications in the shipwright officers in Her Majesty's service than had been shown previously. The experiment has had a very promising success, which time will doubtless increase, since both the practicability and the advantage of higher educational qualifications are evident. The renewed organization and establishment of means to elevate the intellectual character of the professional officers and artizans in the dock-yards, generally, are calculated, in time, to exhibit these establishments under a new phase.

With reference to the direct efforts which have been made for the advancement of naval architecture, it is not unworthy of notice that the only important series of experiments that have been made in England were undertaken by the late colonel Beaufoy, in connection with a society for the improvement of naval architecture, formed in London in 1791, and quite apart from the encouragement and aid of government, to whom the importance of the object was frequently, but in vain, represented by colonel Beaufoy. The finances of the society were exhausted before its objects were accomplished, or even, as it seems, extended beyond the making of experiments, for determining the law of the resistance of fluids, in the Greenland dock; but when public means failed, colonel Beaufoy carried on the experiments, and performed all the labours connected with them at his own expense; and, after his death, the result of those labours was presented to the public by his son, Mr. Henry Beaufoy, in a large quarto volume, gratuitously distributed: an act of munificence in favour of science worthy of the disinterested labours of his father, and of which there are few examples.

A HISTORY,

ETC.

The importance of the science and the practice of ship-building to an insular kingdom, and the extent to which they must, in the course of time, affect its position in the scale of nations, can scarcely be overrated. Although the power and prosperity of some of the ancient states were materially affected by their relative maritime condition, yet it has been reserved for modern times to witness the height of that distinction in power, wealth, and influence, which the command of the seas, and a countless commercial navy, may, under divine Providence, confer on an island of so restricted limits as Great Britain. In the early periods of the history of this country, its strength was but very gradually consolidated. But, at length, when international unity gave freedom and energy to enterprise, both in war and commerce, in which large fleets were necessarily employed, the country advanced rapidly towards that eminence by which it has been distinguished amongst the nations of the earth; and which has been successfully preserved ever since it was first attained.

It is worthy of remark, that with scarcely an exception, the territories which the English have taken possession of, colonised, and retained as a permanent part of their dominions, have been acquired principally by means of their fleets. That the commerce, the colonies, and the fleets of Great Britain are mutually dependent on each other, and are necessary to each other for protection, support, and efficiency of power, to a great extent, is a proposition which no arguments are required to establish. And in the present state of maritime and commercial enterprise in Europe, the effectiveness of our fleets, both national and mercantile, must be regarded as the firmest national guarantee for the progress and stability of our prosperity and power.

If we refer to the cities and states which have been the most eminent, in both ancient and modern times, for extensive commerce, and consequent opulence, it will be seen that their prosperity has, to a most material extent, been connected with their means of carrying on a traffic by sea; and that wherever such means have been used with sufficient freedom and energy, the result has generally been most beneficial. If continental states and cities bordering on the sea, or connected with it by rivers, flourished in proportion as they employed maritime, rather than land conveyance, how immensely important must it be to England, that derives so large a portion of her wealth and power from external sources, to study the highest degree of improvement in the means which so eminently conduce to this national consequence, greatness, and wealth,—advancement and improvement in marine architecture.

The origin of marine architecture is lost in the recesses of antiquity; and we are left to the uncertainty of conjecture with regard to the first use of floating bodies for conveyance. It may, however, be readily conceived that, without the means of investigating the properties of floating bodies generally, such experiments only would be made as necessity might lead to,—and those with the most simple kinds of craft that were sufficiently buoyant for crossing rivers with safety. (*Plate* 1, *Fig*. 1.) The experience of benefits derived from this mode of conveyance would necessarily call for the aid of ingenuity,—and improvement would follow. And a raft of more capacity, constructed of several parts, might precede any description of canoe, (*Plate* 1, *Figs*. 2, 3,) even that formed of the trunk of a tree, rudely shaped on the outside, and hollowed within. (*Plate* 1. *Fig*. 4.)

It is evident that, when a very large portion of the arts which are subservient to the convenience and comfort of man, were in a rude state, the progress of ship-building could not be very rapid. Successive ages doubtless contributed their improvements in the construction of vessels, before such fleets could be produced as those which rendered Tyre so celebrated. In the progress of the art, the builders would forget the original floating conveyance which their ancestors had employed; and, intent upon improvements, they would disregard the inferiority which they were able to excel. Navigation, also, in its earliest efforts, must have corresponded to the imperfection of the art on which it almost entirely depended. The two arts, then, in their correspondent relation of support and dependence, proceeded together; and each increased in importance and utility. This appears to have been the condition of marine architecture when Tyre flourished through her maritime industry and great commercial opulence. It is not known in what descriptions of vessels the traffic of this ancient city was carried on; but knowing the voyages they performed, loaded with merchandise, we are led to conclude that they were built with a considerable degree of strength and capacity.

At a very remote period, Egypt, it is said, was engaged in a course of traffic with India; this traffic was carried on by sea, between the Arabian Gulf and the western shores of India; and, from the shores of the Arabian Gulf to Egypt, the merchandise was conveyed by land. This establishes the fact of very early navigation in the Indian Ocean; whether this navigation was carried on by the Egyptians themselves, or whether they extended their commerce to so distant a country as India by the intervention of foreign aid in vessels and mariners. The latter supposition appears the most probable; as the ships, if they had belonged to the Egyptians,

LOGS, RAFTS AND CANOES.

FIG. 1.

FIG. 2

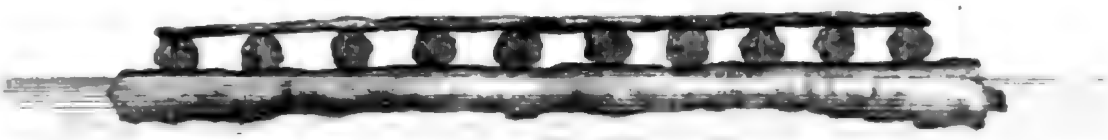


FIG. 3.

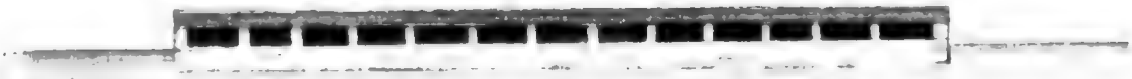
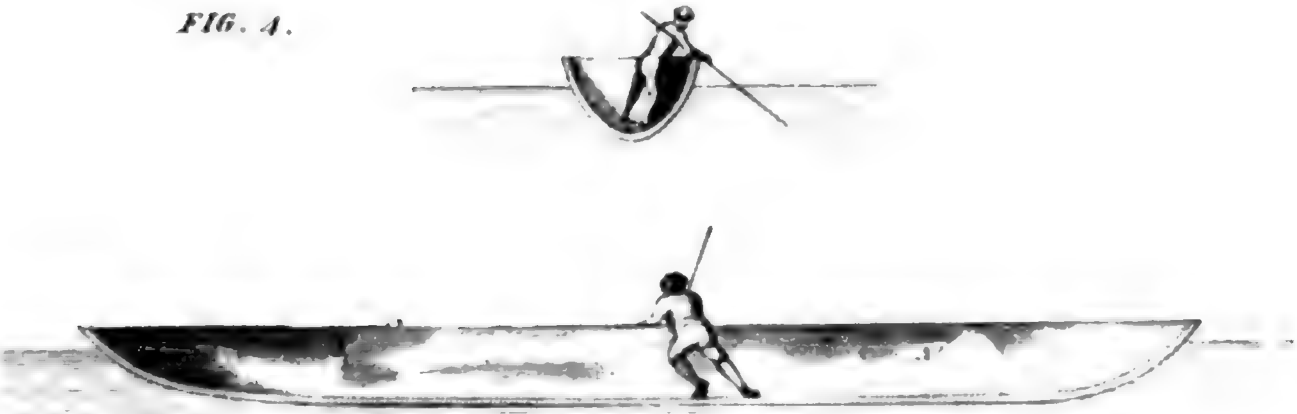


FIG. 4.



might be supposed to have been built nearer their own country, and in that case they might, with greater advantage, have brought their cargoes into the Red Sea, and thus have avoided the tediousness and danger of crossing the deserts. This, at a period soon after the establishment of the Egyptian monarchy, was doubtless a great effort, by whatever people it was made; as the timidity and inexperience of that age rendered it necessary for ships to pursue a slow and dangerous course within sight of land, and the want of intelligence and skill made it more dangerous to commit themselves to the uncertainties of the boundless ocean. But it does not appear that this commerce was carried on for a long period; but that as the Egyptians became the victims of debasing prejudices, their aversion to the sea overcame all considerations of advantage arising from distant foreign commerce. They contented themselves with the produce of their own fertile country, and with that of those countries which their caravans were sufficient to trade with; and, at the same time, they excluded from all intercourse with themselves, those foreigners who were desirous of trading with them from other parts of the Mediterranean.

The Phœnicians became the most distinguished people of antiquity for their enterprising character, their mercantile habits, and their maritime voyages. The insular Tyre succeeded to the city of the same name, which had been destroyed, and became the centre of commerce and "the mart of nations." The opulence of Tyre was a theme on which the ancients dilated; with animated fervour she was called "the golden city;" her arts and manufactures contributed also greatly to her renown, and she was styled "the mother of crafts." But for the variety of her merchandise, the extent of her influence, and the abundance of her wealth, she was dependent almost wholly on the commerce which she carried on by sea. This eminent city enjoyed a long period of great prosperity; and had ages of success, unclouded by the emulation and envy of a rival, and surpassed her predecessor in name, in whatever was great in commerce, arts, and intelligence.

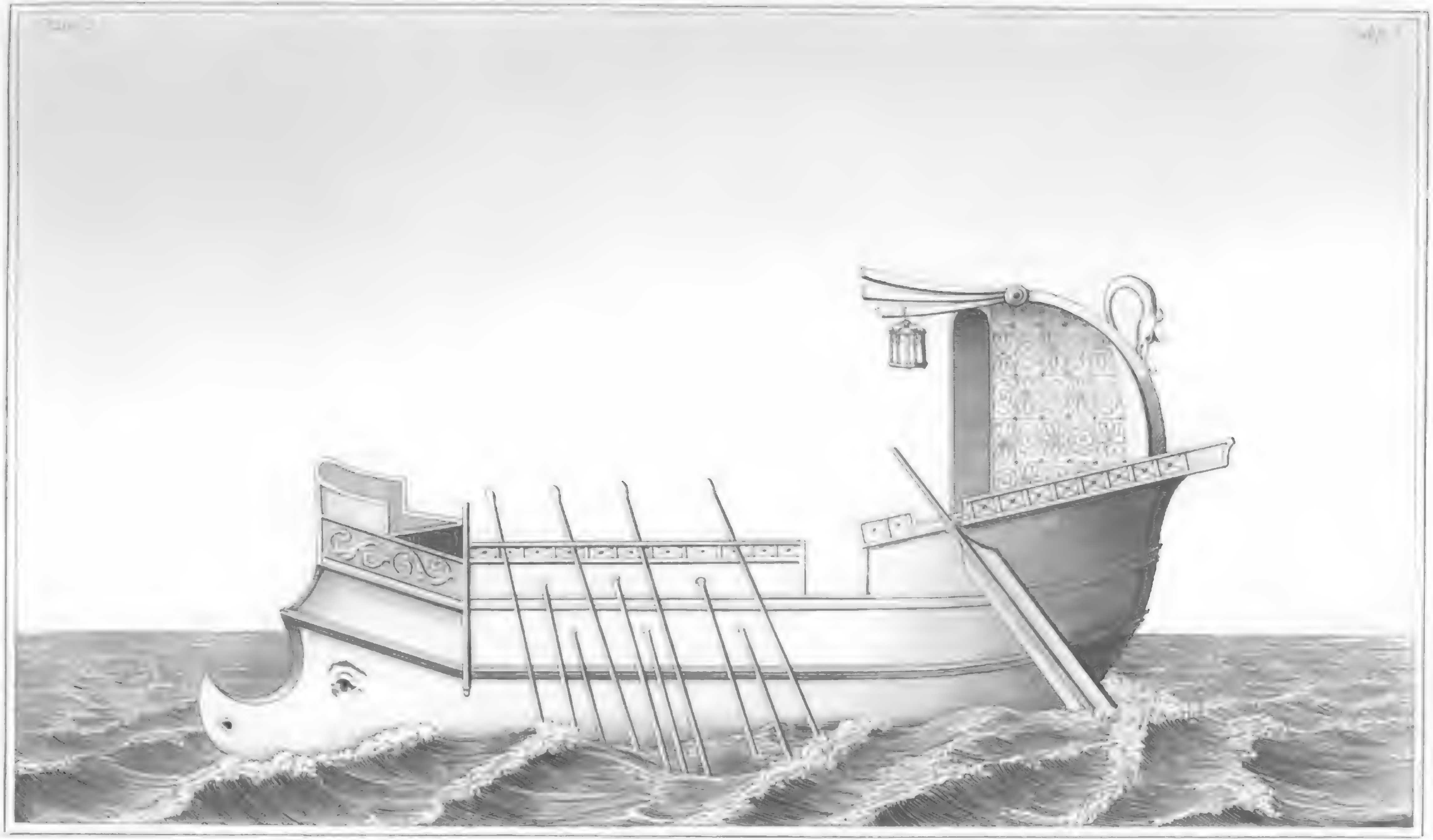
Commerce was the object for which the Phœnicians held maritime pursuits in estimation. The northern coast of Africa, and the southern and western parts of Europe, were places of intercourse and traffic, from which merchandise was imported into Tyre. And it has been considered by some writers, that the Phœnicians found purchasers for their wares, in the Syrians who are supposed to have carried on a considerable trade overland with the countries towards the east. They not only devoted themselves to commerce with the greatest diligence, but they aimed with the utmost cautiousness at preserving its advantages by the sea, entirely to themselves. And they are said, for this purpose, to have been extremely careful in their efforts to conceal from others the destination of their fleets, and to keep them unacquainted with the situation of distant ports to which their voyages were performed; when a vessel was in sight which was regarded as a spy, they would incur the greatest hazard, even the loss of their vessels, rather than lead others into the paths of opulence, which they had discovered by persevering enterprise, and from the advantage of which they were most anxious to exclude all rivalry.

A writer of the present day states, that "their larger vessels were of two sorts, being divided into round ships or *gauli*, and long ships, galleys, or *triremes*. When they drew up in line of battle, the *gauli* were disposed at a small distance from each other in the wings, or in the van and the rear; whilst their *triremes* were contracted together in the centre." The construction of the ancient vessels is but very vaguely expressed by the names they bore. The term *trireme* signified that three tiers or banks of oars were used to propel the vessel that was so designated. But in what manner the tiers of oars were disposed, appears to be extremely difficult of elucidation. Various conjectures have been formed, and much ingenuity employed to determine this point; but a number of considerations which are not very obviously reconcilable, when applied to the most important of the ancient vessels that were propelled by oars, make us form our conclusions on this subject with some degree of diffidence. The accompanying engravings of triremes have been given by different authors, from information or sources to which they had access. They are given here merely as illustrations of what it has been conceived this description of vessels was, without much confidence in their accuracy. (*Plate* 2, according to Bafius, Schœffer, and others.)

It is concluded from some passages in ancient authors, that the Phœnicians extended their voyages as far as Britain, or at least the Scilly Islands, which the *Cassiterides* to which they traded for tin, are supposed to have been. But on this point the information that has come down to us, although it may have a tolerable degree of probability, falls short of certainty. There can be little doubt that they visited all those parts of the Mediterranean and the Black Sea, where they found adequate inducements in traffic. But beyond the Straits of *Gades*, or Gibraltar, their course appears to be, to a great extent, a matter of conjecture. The fact that they traded to the more southern parts of the world, is highly probable, if not absolutely certain. The possession of a convenient port in the Red Sea enabled them to build ships to navigate the Indian Ocean. The merchandise which these ships obtained in either Africa, India, or the islands of the ocean, was brought to Elath, an important commercial town on the shore of the Red Sea. This place continued during successive ages to be a famous seaport, from which mercantile fleets made long voyages, and brought into it the produce of distant regions, enriching the countries to which it happened to be subject.

This was the case in the reigns of David and Solomon, whose fleets sailing from Elath, brought back from distant parts immense wealth in precious metals and stones,—by which the kingdom of Israel was raised in opulence beyond all precedent,—besides other articles of luxury and gratification. This

AN ANCIENT TRIREME, ACCORDING TO BAYFIUS



traffic appears to have been carried on in connection with the Tyrians, whose ingenuity and enterprise were known and appreciated by David and Solomon. Hence it appears that the possession of means to carry on an extensive commerce by sea, and the diligent use of those means, led to the aggrandisement of the country to which the trade of this place was attached. "Ships of Tarshish" appears to have been a general phrase for ships of considerable magnitude. Probably the celebrity in building ships to which the people of Tarshish or Tarsus, in Cilicia, had attained, rendered the application of the term distinctive of some superiority by which they were characterized; and thus the appellation became distinctive of large ships in general. Those which performed voyages of three years from the Red Sea, are called likewise "ships of Tarshish" or "Tharshish."

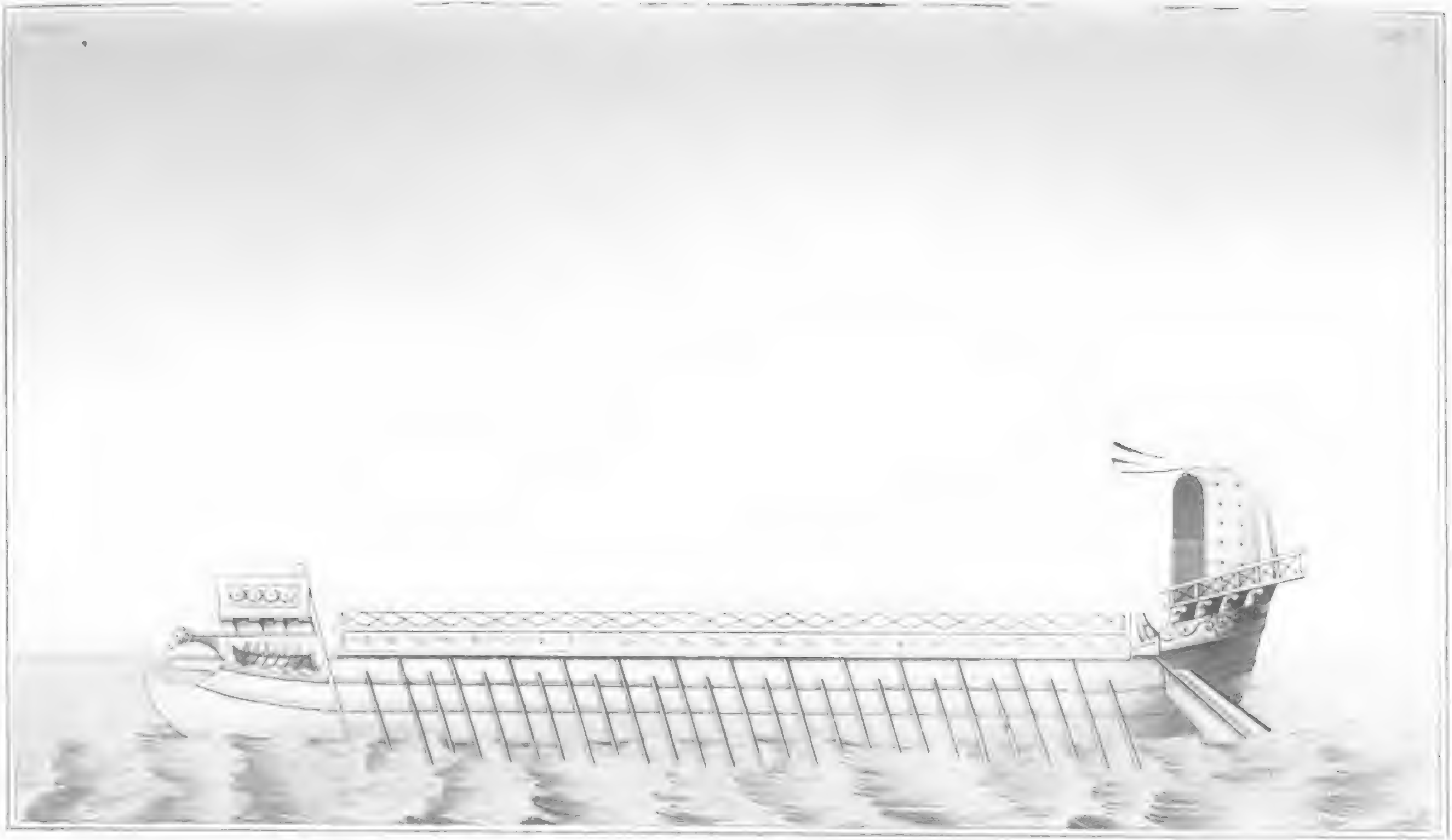
According to ancient authors, some extensive voyages were performed from the Red Sea. Herodotus and Pliny record similar voyages, as that undertaken and performed in the reign of Necho, king of Egypt. Herodotus, it appears, received his information from some Egyptian priests, and discredited their testimony on the ground that the navigators affirmed, that when passing to the south of the African continent they saw the sun towards the north; a statement which appears to be strong evidence of the authenticity of the narrative. Three years were occupied in making the circuit of Africa,—the Phœnician voyagers returning by the Pillars of Hercules, and up the Mediterranean to Egypt. Other voyages of similar character were performed at subsequent periods. And Carthage, the offspring of Phœnicia, sent out fleets on voyages of discovery to the north and south. After they had entered the Atlantic Ocean, they are said to have traced the western coast of Europe, and to have visited Britain; those that took the southern course, advanced, it is said, nearly to the line, examining in their progress the coast of Africa; and discovered the islands in the Atlantic Ocean, which in modern times have been called the Canaries.

Hitherto ship-building and navigation have been considered in immediate connection with the engagements of commerce and discovery; as these two pursuits, so intimately connected, appear to have been the only objects in which fleets were directly engaged. For although the Phœnicians sometimes committed acts of violence and piracy, yet their object in doing so seems to have been to prevent any from following them to their destination, besides their friends and colonists, as the Carthaginians and others; and to preserve to themselves the valuable secret.

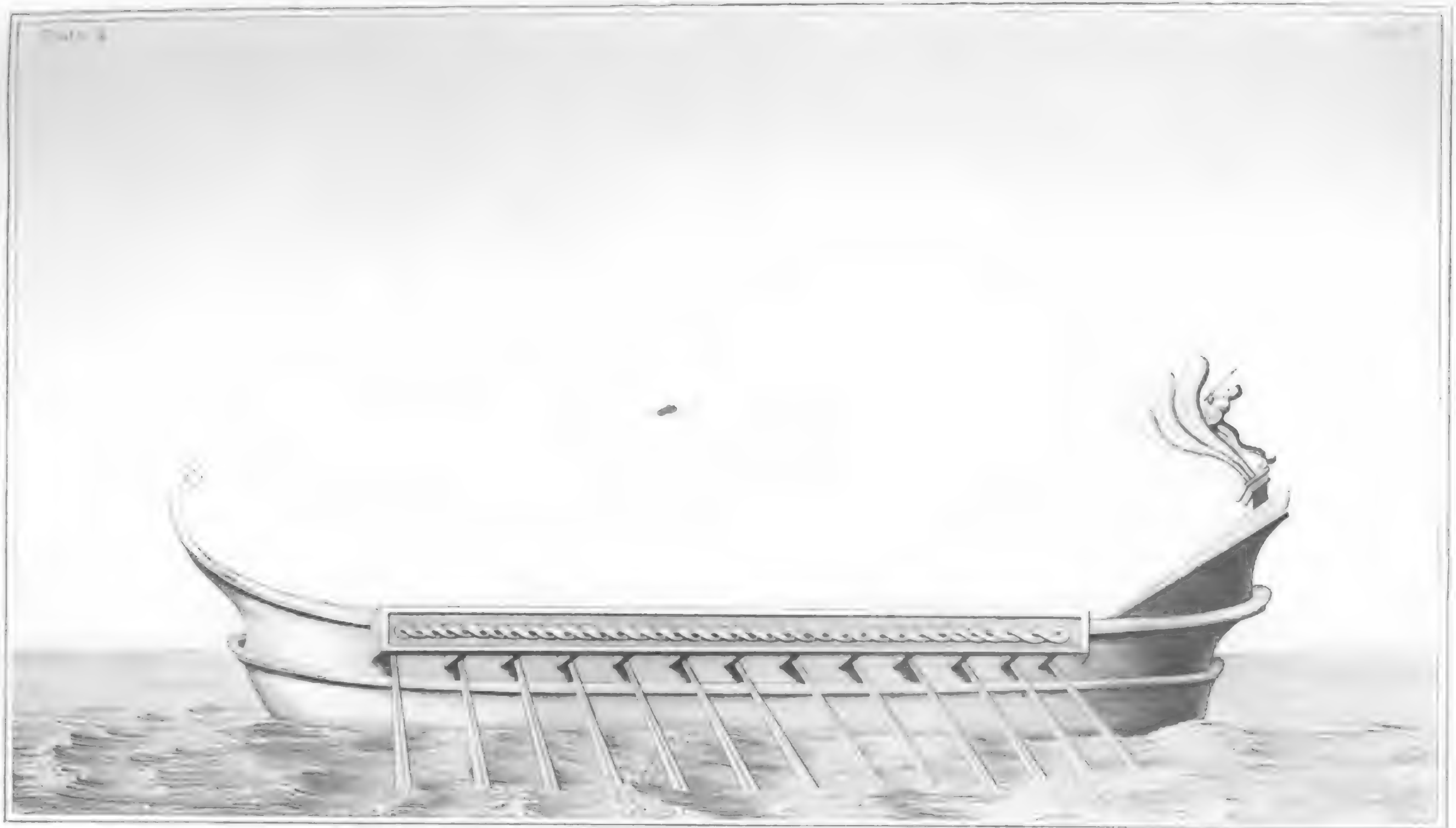
But when a knowledge of the art of ship-building was acquired by the Greeks, it became subservient to very different pursuits. The Greeks, eminent for their refinement and greatness, were jealous of any rivalry in their neighbours which might elevate them to similar distinctions. The intercourse which tended to equalize the advantages of different countries, to exalt their intelligence, and refine their manners, was inconsistent with the supremacy of one small nation in the midst of the earth. Addicted to arms, and glorying in the elevation to which their arms had raised them, they would readily employ the arts of ship-building and navigation, for the purposes of war, to render themselves the more formidable. Poetry and history concur in showing in what estimation the power derived from a knowledge of these arts, was held by the Greeks. The glowing imagination that was employed to embellish the narrative of the voyage performed by the ship *Argo,* is evidence of the glory that was supposed to have been derived from the successful expedition of Jason. Let, however, the whole of this tale be regarded as a fiction, still the manner of celebrating even a fictitious adventure, shows the regard which is attached to its analogies in reality. The testimony of antiquity assigns to the earliest efforts of navigation by the Greeks, the character of violence; either in lawless descents for plunder on neighbouring states, or in open and equal war. And until the time of Alexander, the maritime power of Greece seems to have been employed principally in war. But when that great conqueror, in his eight months siege of Tyre, witnessed the results of commercial pursuits in the immense wealth of that city, he became ambitious to add the riches of commerce to the distinctions of military conquests. With that view he built Alexandria in Egypt, after he had subdued that country under his own sway. By this means he considered the traffic of the East and West might be secured. And such was the success of this measure, that it is said that the diversion of commerce which it led to, was more injurious to the Tyrians, than the destruction of their city which had preceded it.

The Greek vessels bore the general name of galleys; but this name was applicable to vessels of considerably varied capacity and power. They were distinguished according to the arrangement of oars, by which they were propelled; as the *bireme* (*Plate* 3, from Bafius) with two tiers of oars, although Bafius gives a *bireme* with one tier of oars only (*Plate* 4); the *trireme* (*Plate* 2) with three tiers, the *heptereme* (*Plate* 5), and so on, according to the number of banks of oars that were used. But those who have endeavoured to determine what was the description of the ancient galleys, have found great difficulty in the investigation of the subject, owing to the uncertainty of the manner in which the rowers were placed. Endeavours have been made to produce plans in which it has been attempted to reconcile the various ideas associated with the ancient galleys. But the most probable appears to be that which supposes each bank to consist of a given number of oars placed obliquely, with such a perpendicular distance between them, as to allow the inner end of the second oar, being worked, to pass clear of the head of the man who was working the first; and so on successively, whether the tier of oars consisted of three, four, or five. On this supposition the number of tiers of oars would relate only to the length of the galley, other considerations in her construction not requiring to be materially varied. They were doubtless improved upon by the Greeks, during the lengthened period in which science and the arts flourished amongst them.

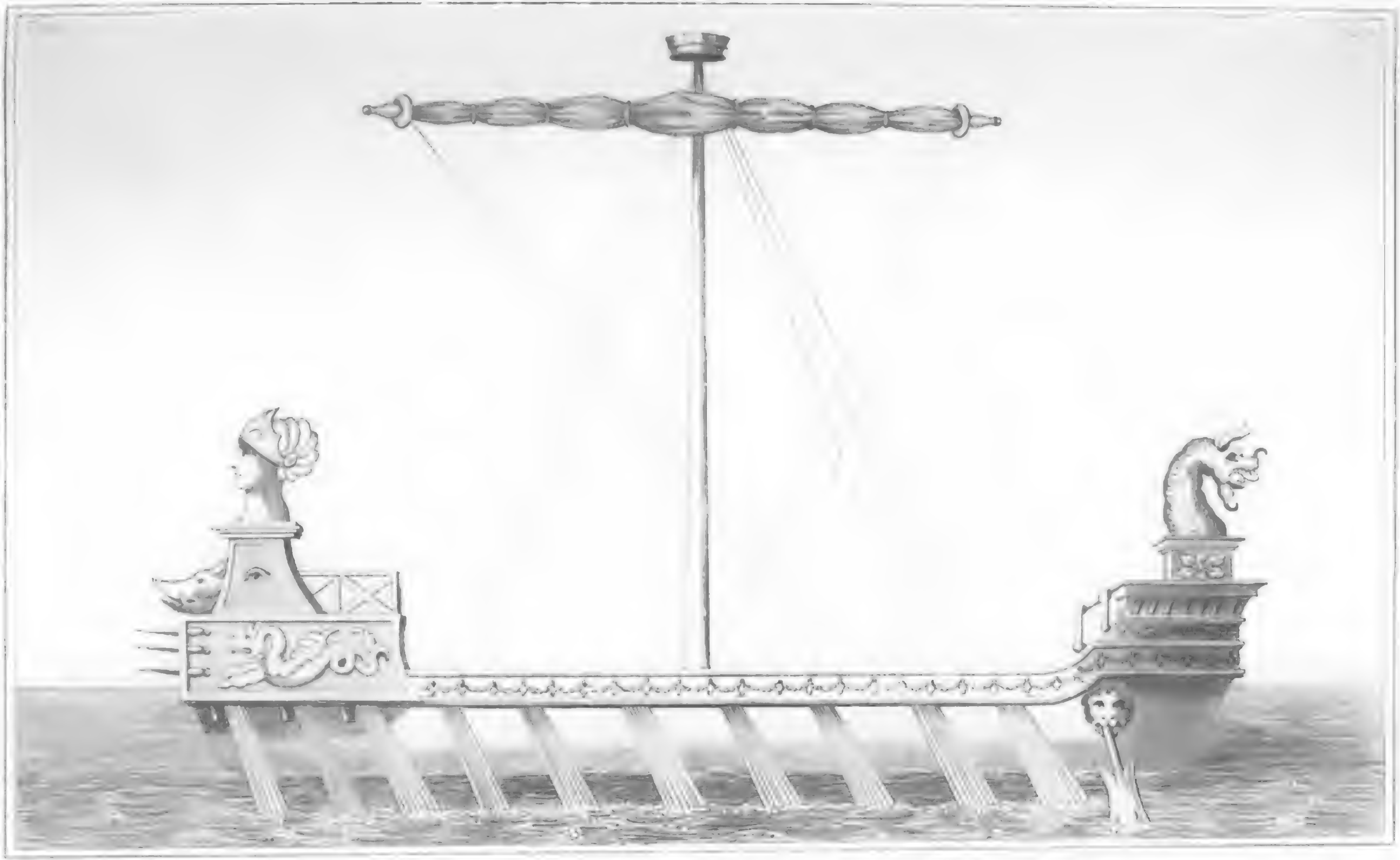
AN ANCIENT BIREME, WITH TWO TIERS OF OARS, FROM BAFIUS.



AN ANCIENT BIREME, WITH ONE TIER OF OARS. FROM BAFIUS.



AN ANCIENT HEPTEREME, FROM BAFIUS.



It is not now possible to arrive at any accurate knowledge of the steps by which the Greeks improved the construction of their vessels. But the very superior character of those which composed their navies in the most flourishing periods of Grecian history, shows that naval architecture must have been studied with a reference to scientific principles, and with the same zeal for eminence that led them to excel in other arts and sciences.

Until a comparatively late period in the empire of Rome, the Romans held maritime pursuits in the lowest estimation; being almost wholly unacquainted with the art of building, and esteeming the life of a mariner unworthy of a citizen whose rank would entitle him to be admitted into the legions. Their military successes raised them, by a progressive advancement, to that signal eminence, in which they held almost every civilized state and nation in subjection. And what remained for a navy to accomplish? One city was yet its rival. Carthage, the opulent and brave city, the offspring of Phœnicia, whose commercial population imitated the habits, and emulated the greatness of Tyre, was the conspicuous object of envy and hatred of the Romans. From the time when Tyre ceased to hold the sovereignty of the sea, the Carthaginian fleets were supreme in every part of the Mediterranean. And it is said that the Romans acquired a knowledge of constructing vessels from a Carthaginian galley that ran ashore on their coast; but the time when they first turned their attention to naval pursuits is uncertain. It appears, that before the Romans attained to great power, they were subject to considerable restriction. Burchett, in his history, mentions a treaty between them and the Tarentines, by which the Romans were bound not to extend their navigation beyond certain limits. The fact of such a treaty having been formed, implies the possession of vessels by the Romans, and that the naval power of that people was low. The notices which we have of the exercise of that power, render it highly probable that when they advanced to some degree of importance at sea, their navy was quite a subordinate institution in relation to the other establishments of the empire. The rapidity with which they built a considerable number of vessels when a fleet was required, renders it highly probable that no regular naval establishment was maintained by them; but that, when war rendered an expedition necessary, the means of undertaking it were provided in the most expeditious manner. And it does not seem that such a practice would involve any material inconvenience in the ages of Roman splendour, when few navies existed, and naval warfare was but little practised, and when therefore there was little opportunity of gaining by sea that distinction in arms, which was held in such high estimation by the Romans; and the inferior regard which was had to commerce, supplied few incentives to those pursuits which would require fleets to be in constant fitness for sea. The widely-extended conquests by which the Romans brought so many foreign states under their own sway, at length rendered an alteration, with regard to naval power, highly important; and as the service of a navy became an object of consideration, they showed the greatest ardour to establish their fame as firmly by their maritime achievements as they had by their military conquests. And when opposed to a powerful enemy, they employed large fleets, in which they exhibited a most formidable array of power. The civil, as well as the national wars, in which they were engaged, show with how much readiness and energy fleets could be prepared and employed. Galleys appear to have formed the principal part of their fleets; but how far they carried improvement in the construction of that description of vessels is, perhaps, not to be easily ascertained. Biremes, triremes, and quinqueremes, appear to have been in very common use.

But when the dominion of the world was attained by the Romans, and they became masters of the trade of the East, their vessels were, no doubt, constructed with a greater regard to the violence of the ocean. For it appears from Pliny, that they became acquainted with the periodical prevalence of the monsoons, and performed their voyages from the Arabian Gulf to India and back, at the seasons which were most favourable to the navigation of the Indian ocean. Yet as it was the custom of the Romans to allow the people in the provinces brought under their own power to continue their habits of industry and traffic, with no other restriction than a contribution which they required from the profits of it to enrich themselves, it is probable that the provincial citizens of Alexandria continued the Indian trade, and that the Romans themselves had but little to do with it.

The Romans were the first of those ancient nations who visited Britain, that have left any account of the island which they visited. Cæsar, the conqueror of the Britons, described them. They were then in their rudest state. The insular character of their country must have led them to acquire a knowledge of the sea. They were in the habit of crossing the Channel for commercial purposes, not only with Gaul, but with other nations farther north. The ancient Britons appear to have had a high regard for commerce; they not only practised it themselves, but they were visited by foreigners who traded with them. Nor were any persons allowed to visit their shores, except they came for purposes of traffic; and even these were regarded with so much jealousy, that they were allowed to go only so far as the business they were engaged in required, and were not permitted to have access to the interior of the island. We read of the boats of the ancient Britons being formed of wicker work, covered with hides; and these were, perhaps, commonly used for the purpose of fishing in the rivers. But it must by no means be supposed, that the ancient inhabitants of this island possessed no vessels of superior construction and power. For it appears a remarkable fact, that from the most remote period to which the history of the British islands extends, the people who could command the British Channel could command the islands. The Britons themselves maintained such fleets as enabled them to exercise this power. It was the importance which they derived from the maintenance of fleets, that rendered their alliance valuable to their continental neighbours. And they were in the habit of maintaining a commercial intercourse with the countries on the continent, and of assisting their friends on the opposite coast with the service their vessels could perform, in the wars in which they were engaged. The assistance they rendered to the Gauls is conclusive evidence of the regard which was had to a maritime establishment, and of the existence of power in that of the Britons. But the invasion and conquest of their island by the Romans, under Cæsar, reduced to a very low state, if it did not destroy the maritime power of these people. And when the Romans ruled the island, the possession of a similar force became of the first importance to the stability of their possession. For the northern nations of the continent of Europe now had navies, and were in the habit of making piratical expeditions against their neighbours. This violence had risen to a mischievous height in the latter part of the third century; and it was resolved, by the Emperor Maximian, to make a strong effort to suppress it. For this purpose a large fleet was fitted out, and entrusted to the command of Carausius, whose experience pointed him out as highly qualified for the service. *Gessoriacum* (Boulogne) was the principal station of his ships. This officer had not been long invested with the trust, before he was accused of violating it, by misappropriating the prizes he obtained; and Maximian ordered him to be put to death. Intelligence of this order reached him so early, that he had an opportunity of escaping the consequences of it. He therefore sailed with his fleet across the channel, and landed in Britain. Here he engaged the Roman legion that was in the island to support him in his pretensions; and he caused himself to be proclaimed emperor. A fleet was the only force on which he could depend for maintaining the dignity he had assumed, and he therefore paid the greatest attention to the improvement of his navy. Being strong in the dominion of the sea, he completely vanquished a fleet which the joint emperors of Rome sent against him, and compelled them to acknowledge his independent sovereignty, which he maintained for seven years, at the end of which he was assassinated. It was during the period of his government that the fleets of Britain acquired a more extensive power and influence than they had before attained; for they not only rode triumphantly in the narrow seas, but extended their voyages to the shores of Africa, and assumed the right of giving laws in the Atlantic ocean.*

Soon after this, the maritime power of Rome declined rapidly. The naval interest of the empire was neglected, and the fleets went to decay. A civil war, in the beginning of the fourth century, called into activity the utmost naval force that could be obtained. Constantine, in order to secure to himself the whole Roman empire, against the ambitious objects and intrigues of his brother-in-law, Lucinius, whose station in the army was such as to render him a formidable enemy in the state, involved his country in a civil war. When these rivals for the empire collected their fleets in the year 323, it may be supposed that the forces engaged on both sides comprised probably the entire naval force of the Roman empire, and its provinces bordering on the Mediterranean sea. The fleet of Constantine consisted, according to Zozimus, of 200 small warlike vessels, of 30 oars each, supplied by Greece, and above 2000 transports, of the size of which we have no information. That of Lucinius is stated, by the same author, to have consisted of 350 vessels, eighty of which were furnished by Egypt, eighty by Phœnicia, sixty by Ionia and Doria, thirty by Cyprus, twenty by Coria, thirty by Bythinia, and fifty by Africa.

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* Macpherson, Vol. I. p. 204.

It was not long after this, that an extraordinary effort was made to construct a vessel of unusual dimensions for the conveyance of an obelisk from Egypt to Rome. This was the obelisk which had been placed before the Temple of the Sun at Heliopolis, and which, from its immense magnitude, had been spared by those foreigners who had previously acquired and held the dominion of Egypt. The removal of this splendid remnant of ancient art appeared to Constantine worthy of a great emperor. He caused it to be taken from the pedestal on which it had stood from the remote periods of antiquity, and conveyed on rafts to Alexandria. And though the death of Constantine arrested the progress of the undertaking, it was not relinquished; for the son and successor of Constantine determined to have it conveyed to Rome. For this purpose he caused a ship, of suitable capacity, to be built. The obelisk was 115 feet in length; and it has been said that, upon the most moderate computation, the weight of it could not have been less than fifteen hundred tons. Now, a vessel suited to the conveyance of this obelisk, must have been 130 or 150 feet long, and of at least 800 or 1000 tons burthen, and the strength of the fabric must likewise have been very considerable to be capable of receiving on board so ponderous a mass of material.

Early in the next century the Vandals became formidable in the progress of their wars and ravages in the west of Europe. Spain was conquered by them. In the year 439 they passed over to Africa, under Genseric; and, conquering Carthage, that city became the seat of the Vandal empire in Africa. Not satisfied with conquering the Roman provinces, Genseric threatened the safety, and even the existence of the Roman power in the west. Theodosius was at this time the Roman emperor in the east; and he had been careful to secure, as much as possible, the use of fleets to his own empire and its provinces, by attaching the penalty of death to the offence, in any of his subjects, of teaching the art of ship-building to any foreigners who were not under the Roman sway. And whilst the force of law was so severely restrictive, the building of vessels in the empire of

Rome appears to have been attended to with considerable care. For when Theodosius prepared to withstand the arms of the Vandal prince, eleven hundred large ships, it is said, were fitted out to join the forces of the west. But this armament proceeded only as far as Sicily, and in the end it accomplished no part of the object for which it had been designed. The Vandals, therefore, invaded Italy, and sacked the city of Rome in July, 455. Thus, whilst Theodosius had with considerable policy provided for the defence of his empire, a want of skill in the conduct of his officers rendered all his naval preparations unavailing, in the service to which they had had reference.

Subsequently to the disastrous invasion of the Roman empire, the naval power of the Mediterranean declined from its importance, as warfare was confined principally to the land. And the only people who possessed a fleet of any consequence in that sea, for some time, were the Saracens. Little is known of the mechanical skill employed in the construction of their vessels; nor does it appear that they maintained a constant succession of fleets in the Mediterranean. Yet whilst they paid a due regard to the pursuits of navigation, they were very formidable in that sea. Twice the city of Constantinople was besieged by their fleets,—in the years 668 and 716. The fleet employed on the latter occasion amounted, it is said, to 1800 vessels, and twenty of these, which were called large ships, carried a hundred soldiers each. The distinction marked by this statement implies the inferiority of the rest, a large number of which were probably of very small dimensions. Both of these fleets were almost entirely destroyed by the famous Greek fire, which, when it was poured forth by the besieged upon the ships, burnt with inextinguishable force, unchecked by the water that was thrown upon it. Notwithstanding these defeats, the Saracens continued to be the most powerful people in the world, maintaining a supremacy upon the sea, as well as by land; and supporting their unrivalled greatness by an extensive commerce, of which they had almost the entire control, both in the Mediterranean sea and in the Indian ocean.*

About the middle of the eighth century, the Saxons and their associates, who had settled in Britain, appear to have entirely changed their national character and pursuits. Their maritime power had been neglected; and their vessels, not having been for a long time called into use, were allowed to fall into a state of perfect inutility on the shore. And the consequences of this neglect verified the opinion which had long before been held,—that he who commanded the narrow seas, might command the British Islands. For, taking advantage of the defenceless condition into which these islands had sunk, those people on the shores of the European continent who had descended from the same ancestors, as the Danes, Norwegians, and Normans, and who, having become masters of the northern seas, carried on an extensive practice of piracy, visited the British coasts, and gratified their rapacity and their tyranny; whilst the natives, having neglected the means of defence, were able to offer no effectual resistance; and consequently, became involved in numerous and severe disasters.

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* Macpherson, Vol. I. pp. 241—5.

The following is the description of a galley built about this time, as given in Mr. Strutt's Chronicles of England: "The form of the Saxon ships at the end of the eighth century, or in the beginning of the ninth, is happily preserved in some of the ancient monuments of that date. They were scarcely more than a very large boat, and seem to be built of stout planks laid one over the other, in the manner that is in use in the present time. Their heads and sterns are very erect, and rise high out of the water, ornamented at top with some uncouth head of an animal rudely cut. They have but one mast, the top of which is decorated with a bird, or some such device. To this mast is made fast a large sail, which, from its nature and construction, could only be useful when the vessel went before the wind. The vessel was steered by a large oar with a flat end very broad, passing by the side of the stern: and this was managed by the pilot, who sat in the stern, and thence issued his orders to the mariners." (*Plate* 6.)

During those ages of intellectual captivity in Europe, when refinement, and almost everything that was great and ennobling in science and art, became neglected and unappreciated, it is in vain to look for any of those efforts, by a series of which a nation rises into conspicuous power and importance. Wherever civilization had distinguished society, and the influence of Rome had prevailed, there was now an almost entire reign of ignorance, and whatever is bad in association with it. Few of the states of Europe cultivated the arts by which a spirit of enterprise is engendered; and those which had not laid aside the practice of maritime occupations, as Genoa, and a few other cities in Italy, felt the influence of the wide-spread debasement which surrounded them; and remained, to a great extent, regardless of those pursuits and enterprises by which cities and countries of old had aggrandised themselves, and stood forth as examples to the rest of the nations. No vigorous maritime enterprises procured the benefits of commerce, or extended discovery and civilization in distant parts. Those cities, however, retained a portion of commerce, and had ships for carrying it on; and on one occasion, in the year 848, when Rome was threatened by the Saracens, they supplied a fleet to defend the city. But the Saracen fleet having been much damaged by a storm, the city was saved without the intervention of the armament which had been engaged for its defence, the force of which was, therefore, never tried.*

In the northern parts of Europe naval affairs received some degree of attention during the ninth century. Their pursuits by sea, which were generally of a practical character, were held in honourable estimation in the

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* Macpherson, Vol. I., p. 254.

SAXON SHIP OF THE EIGHTH CENTURY.

Plate 6

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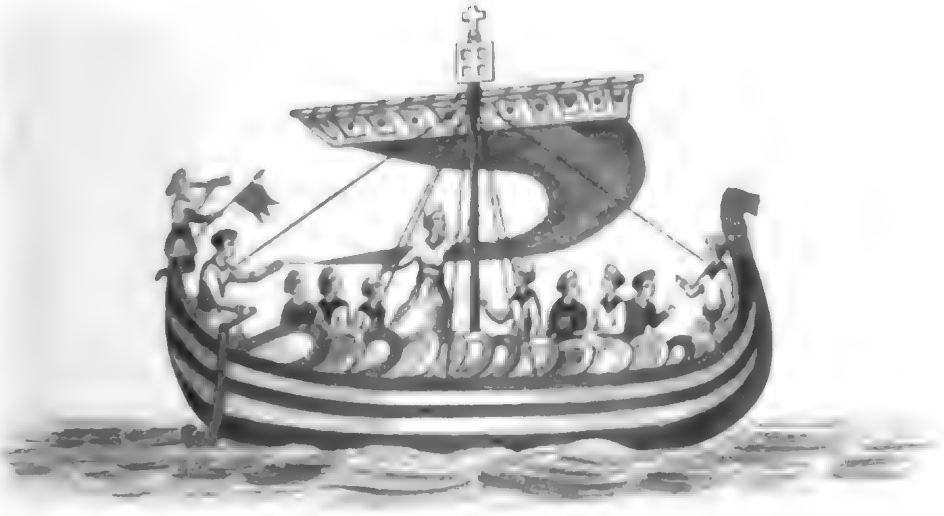

state of society in which they were carried on. Noble families, of which the junior members were incompetently provided for, were not considered to be dishonoured by fitting out vessels and leading a band of men, to make descents on neighbouring shores, and levy contributions, or otherwise enrich themselves, by violently carrying off the wealth of those whose lands they happened to visit. Denmark was the most considerable of the states which pursued maritime enterprises. The rocky and dangerous shores of their country obliged the Danes to have greater regard to the strength of their vessels than some of the neighbouring states; fleets of strong galleys could perform the voyages which they had occasion to make; and such vessels, in some respects, answered the principal purpose for which they were required, better than ships of considerable burthen would have done. In their piratical expeditions, their movements in these vessels were quick, their descent on an obnoxious shore sudden, and their departure easy. And as it was not generally necessary that they should keep the sea longer than the time occupied in making their passage from one coast to another in the Channel, the North Sea, or the Baltic; there were few powerful inducements for them to alter the construction of their vessels materially, until the efforts of navigation should extend their voyages to greater length, or the enterprises of commerce should require vessels of greater capacity.

In the meantime, England was bowed down beneath the oppressive tyranny of the Danes, who now resided in large numbers on the island: nor were any effectual efforts made to overcome them, until the time of Alfred, who ascended the throne in the year 871. The first part of his reign was distinguished by the most deplorable depression of his kingdom; it was a period, indeed, for the most part not of dominion, but of retired concealment. It was, however, in his retirement that he formed the grand scheme for delivering his country from the ravages of its invaders. And when he had succeeded in driving them from his shores, it was sufficiently apparent to him that no army which he could command, however it might be organised, would be able to protect his kingdom from the future ravages of these enemies. He therefore resolved to meet them upon that element, on the dominion of which the security of his kingdom depended; and directed his attention immediately to the formation of a navy, at a time when such a power was almost if not quite extinct in his dominions; and hence this illustrious prince has been justly called the father of the British navy. He disdained merely to imitate those whom it was his aim to conquer; and built galleys almost double the length of theirs; and in every way superior to them. The elevated genius of this distinguished prince appears to have been singularly adapted to the exigencies of so calamitous a period as that in which he lived; for, from the exalted duties of the throne, down to the subordinate duties of constructing a galley, he appears to have distinguished himself by a superiority in performing whatever he undertook. It is recorded that he formed the plan for the construction of these vessels; and that he superintended the building of them, giving the necessary directions to the artificers employed upon them. Some of these galleys had sixty oars, and others had even a greater number.*

The large ships of Alfred were built about the year 897; and the first service in which they were employed was against six Danish pirates of uncommon strength, which had infested the Isle of Wight and the neighbouring coast. Nine of Alfred's galleys were sent out against them; and these vessels, being of superior force to those of the Danes, drove three of them ashore, two of which were wrecked; two others they captured, and one escaped with only five men.† The policy of Alfred appears to have been appreciated by his successors; and the vigour with which it was acted upon in subsequent reigns justified all the importance that he had attached to it.

It is said that when Edgar ascended the throne of England in the year 959, he began his reign by a method of government, which showed that he placed his chief dependence for the safety of his kingdom on the flourishing state of his navy. He established a navy, the elements of which had been previously formed; and encouraged, with the greatest care, a maritime disposition in his subjects. Various accounts have been given of the number of his ships. Roger Hovenden may perhaps be regarded as credible authority in this case, and according to him, the navy of England consisted of three thousand six hundred vessels. These, it is said, Edgar divided into three fleets, with which, during the summer, he sailed round the coast of England and Scotland; and by the vigilance and force of his fleets, constantly stationed upon the coast, he prevented invasion during his reign. There is also a fact mentioned of him by both English and foreign historians, which shows the vigour with which he ruled; that when he had subdued a number of inferior states, he caused eight tributary princes to row him in his royal barge upon the river Dee, whilst he himself managed the helm.

The maintenance of the navy appears now to have been conducted on a more settled plan. The nation became charged with providing vessels sufficient to form a regular establishment. In the reign of Ethelred, who succeeded to the throne, every person possessing three hundred and ten hides of land was required to build one galley; and the owners of more or less land were assessed for the same purpose, with reference to the quantity of land they occupied. These were victualled and manned with choice soldiers; and the principal harbour, which was the rendezvous for the fleets, was that of Sandwich, in Kent.

As the Danes and Saxons increased in power themselves, they became the more formidable in relation to those countries lying within the limits of a moderate voyage: and their piratical excursions, which appear to have been formerly, to a great extent, those of private adventurers, assumed in time more of a national character. Princes and sovereigns at length took the lead in them; and they acquired all the force that would naturally result from such an alteration in the conduct of them. These predatory invasions were deemed an honourable mode of beginning a war; and colonization advanced with the growing power of navies.

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* Burchett, pp. 326-7.

† Charnock, Vol. I., p. 262.

The Danes formed settlements on the coasts of England, Scotland, and Ireland, during the tenth or in the beginning of the eleventh century; and as these settlers were from time to time strengthened by an increase of adventurers from their own country, they became so strong in their colonies, that their residence was a most grievous oppression to the natives. The latter rose at length against their invaders by order of Ethelred the Second, in 1002; many of the settlers were put to death; and the rest escaped that catastrophe by embarking with the utmost precipitation. This measure brought new calamities upon England. Swain, king of Denmark, in order to avenge the death of so many of his countrymen and the expulsion of the rest, invaded England about the year 1013; and being encouraged by many persons of importance who were of Danish extraction, he set up an elective claim to the throne of England. He was encouraged in this bold project, if not originally prompted to it, by a general defection on the part of the Saxon subjects from their king, Edmund Ironside, who retired into Normandy, whence he was recalled by his own subjects in the following year, at the commencement of which Swain had died; and the Danish subjects had declared in favour of his son Canute. The Saxons now supported the right of their own king; and a mutual agreement was entered into between the two rivals, that the survivor should inherit the throne. By virtue of this arrangement the sovereignty of England devolved upon Canute, in the year 1017, Edmund having died shortly after his return from exile.

This transfer of the sovereignty from the Saxon to the Danish line, appears to have been materially connected with the relative naval power of the two contending parties in the country. Previously to this event, the Danes had maintained their possession of territory by the same means that they had acquired it. Beyond the exertion of superior force, they had no certainty of holding it. And it appears, that whilst holding colonial possession of England, they maintained fleets in readiness for service; as when the Saxons rose against them, those only survived the violent attack, who made immediate use of them to return to Denmark. Afterwards, when they had returned to England in greater numbers, they kept up a navy sufficient for what they supposed would be required of it; but as the establishment of the sovereignty in a Danish prince rendered their condition less precarious, they diminished that force by sending home most of their ships, retaining only forty to guard the coast.

The regard which was paid to the navy subsequently to this period, does not appear to have been very great; as, indeed, Canute had not the same occasion for its service that his predecessors had had. Having nothing to fear from

Danish invasions, his object now was to establish his authority and sway firmly in England. It has been supposed that his government was conciliatory, as the Saxons joined, on several occasions, to advance his designs; first, when he fitted out fifty vessels, in 1027, to recover Norway, in which he succeeded; and then, three years afterwards, when he invaded Scotland, both by sea and land, and was also successful in that expedition. The naval power of the country declined still further after this; for, during the latter years of this prince, the navy consisted of only sixteen vessels, a number, however, which might be sufficient for the purposes of the country, whilst its interests had a friendly association with the neighbouring maritime states. This opinion appears to derive a considerable degree of credibility, from the fact that Harold, who, on the death of his father, in 1036, ascended the throne, continued to maintain only the same naval establishment. The reign of Harold extended over a period of little more than four years; and on his death, his brother, Hardicanute, who had been some time in Denmark, came over with a considerable fleet to take possession of the kingdom. After he had ascended the throne, he levied a subsidy for sixty-two ships. And when the navy became settled, the number of ships was fixed at thirty-two, double of the number at which it had been established in the preceding reign.

If, in the generality of vessels built about this time, few considerations were had regard to, beyond those of essential utility, and perhaps a few rude ornaments, still there was in existence a taste for display, and that of a rich and most costly description. For shortly after Hardicanute ascended the throne, Earl Godwin presented to him a galley superbly ornamented with gilding, rowed by eighty men, each of whom wore upon his arm a golden bracelet of sixteen ounces in weight.* But this prince did not live long; and at his death, in 1041, the Danish dynasty in England ceased, after having existed twenty-eight years.

In the reign of Edward the Confessor, little was done by the navy, of which the establishment varied but little from that of his predecessor. Its service was rendered necessary, chiefly against the turbulent family of Earl Godwin, who fitted out a number of vessels, and carried on a series of depredations upon the coast. These were for a considerable time unchecked by the king's fleet; at length, however, an appearance of greater vigour was assumed, by the fitting out of a number of vessels to be employed against the Godwin family; but before anything was done in pursuance of this preparation, the king and this powerful nobleman became reconciled, and no occasion remained for the employment of the fleet.

The ambition of this family, however, had only a temporary repose; when Edward died, early in 1066, Harold, the son of Earl Godwin, seized the vacant throne. This was soon followed by the invasion of England by William,

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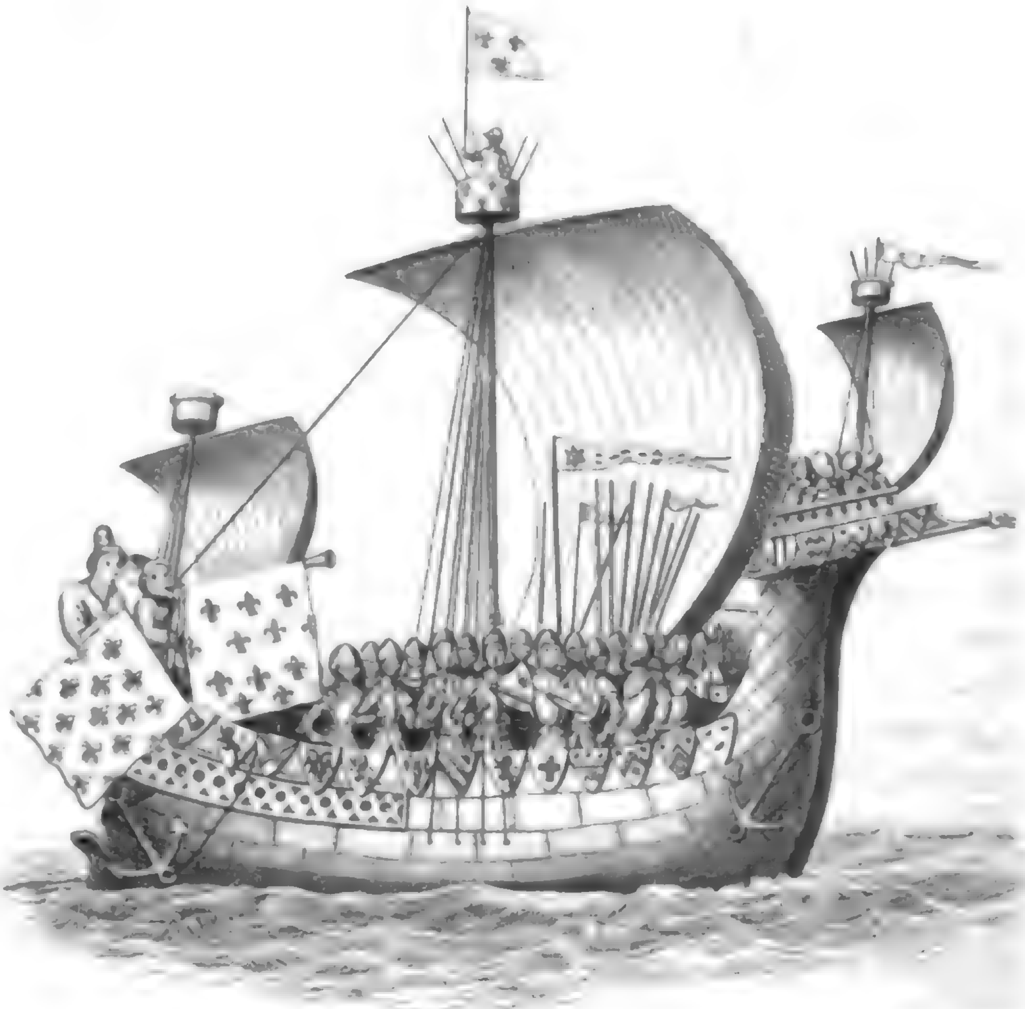
* Charnock, Vol. I. pp. 265, 271; Macpherson, Vol. I. p. 291.

NORMAN VESSEL.

SHIP OF WILLIAM THE CONQUEROR.



Duke of Normandy, which excluded the line of Saxon princes from the throne, transferred the sovereignty to the Normans, and established it in their hands. The army which accompanied William, it is said, amounted to sixty thousand men. The number of vessels employed in the conveyance of them has been variously stated; and there is little doubt that those who state it at three thousand vessels, have exaggerated materially; while those who give the number at nine hundred, were probably below the real amount. But it is not unlikely that the burthen of the largest was less than twenty tons, and that a great part of the armament consisted of vessels of considerably inferior burthen. When the Norman troops had landed, William caused his vessels to be burnt, leaving his army no choice of retreat; and confidently anticipating the conquest of the army that should be brought against him, he considered there would be no further occasion for his fleet. Plate 7 describes one of the vessels that came over to England at this time.

William appears to have been insufficiently acquainted with the requisite means for preserving the tranquil possession of his newly acquired kingdom. The destruction of a naval force left his coast open to the invasion of competitors for the crown. Several fleets arrived, and he had none to repel them; and it was with difficulty that he could rescue his Norman subjects, who were the only part of those whom he governed, for whose welfare he entertained much regard, from the consequences of having neglected to maintain a fleet to prevent the landing of an enemy. An invasion in 1069, by which he had suffered materially, led the king to a greater regard for the navy, and accordingly he collected as many vessels as he could to form a fleet, which he employed in various services, as occasions arose; and in the invasion of Scotland, by sea as well as by land, in 1071. And as a means of ensuring a supply of ships when they should be required, he instituted the Cinque Ports, in 1078.

During this reign, and for a considerable time afterwards, few events of much interest occurred in relation to the naval affairs of the country. Occasionally a fleet was required to perform some service. But the importance of keeping one in constant readiness for occasional services, seems not to have been regarded by the early sovereigns of the Norman line. Two shipwrecks, mentioned by historians, furnish an idea of the capacity of some of the ships which were built about this time. In the reign of Henry the First, a ship was built, under the immediate direction of the king's only son, William Duke of Normandy. On board of this ship the duke, with his suite, embarked to cross the channel. But before the passage was completed, the ship ran upon a reef of rocks, when the prince, and all who were on board, with the exception of one man, perished. The entire number of persons has been differently stated,* varying from two to three hundred. In about the eighteenth year of Henry the Second, a similar catastrophe occurred. The king and his suite having embarked to pass over to Brittany, one of the ships foundered, and it is said three hundred lives were lost. As these ships were employed in the immediate service of the king, or some part of his family or the court, and were probably larger than other ships built in those times, they evidently show that an increase had been made in the burthens of ships since the invasion of England by the Normans. Indeed, this king had the credit of having paid a greater regard to the interests of his navy than had been shown in the reigns of his predecessors. In several expeditions which he undertook, he evinced much energy; and in executing his projects he showed his estimate of the importance of his fleets by depending so much upon them; so that the French historian, Father Daniel, acknowledged that Henry the Second most justly claimed, and undeniably maintained the sovereignty of the sea.* And so jealous was he of the maritime importance of his country, that he prohibited the sale of any British ships to foreigners, and commanded that no English mariner should engage himself in foreign service.†

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* Charnock, Vol. I. p. 327.

The accession of Richard the First, in 1189, led to an extensive employment of fleets. His early concern for the objects of the crusaders induced him to devote his interest, resources and power, towards advancing their designs. Accordingly, in the year 1190, he embarked on an expedition to Palestine, with nine ships of extraordinary size and burthen; a hundred and fifty others, which though of inferior dimensions, were all equipped for war; thirty galleys, and a considerable number of smaller vessels, employed for the conveyance of stores and provisions for the fleet. A dispute which rose to some height between the kings of England and France, whilst they were staying at Sicily, and was aggravated by the king of that island, ended in the reconciliation of the crusading princes, and the forfeiture to Richard of a large quantity of gold, four large galleons, and fifteen galleys by Tancred, the king of Sicily. The spirit of crusading was at its height; and the south of Europe was carried away by the force of it. Those states whose zeal carried them beyond their own resources, hired ships of the maritime cities of Venice, Genoa, and Pisa. These cities, which derived commercial advantages from the fierce and sanguinary aggressions of the rest of Europe, advanced in opulence by letting out ships to the warlike countries which required them, and by the vast increase of commerce which they obtained; whilst those who carried on the war witnessed the waste of their own treasure, and of the lives of their most valuable subjects, without attaining the object on which they were so unjustly intent. But if any advantage was derived from the prosecution of these wars by the English, it might be that of a more extended intercourse and acquaintance with distant parts. And perhaps some improvements in navigation may have resulted from the voyages which were performed up the Mediterranean in the prosecution of these wars; and in ship-building, from an acquaintance with the form and construction of the Venetian and Genoese ships, or those of the Mahommedans, by whom some ships of extraordinary size appear to have been built. An account is given of an engagement which the English fleet, on its way from Cyprus to Acre, had with a very large Saracen ship, which is stated to have been defended by fifteen hundred men. Though vanquished by the English, they were not enriched by her as a prize. She sank, after she had been compelled to surrender; but the cause of her sinking is not stated. The origin of the laws of Oberon is considered by some authors to have been connected with the crusade in which Richard was engaged; and they have associated the benefits which have resulted to navigation from these laws, with this undertaking; but others have fixed their origin at a later date. It has also been supposed that one effect of these wars was, to confine the Saracens within their own countries, by giving them sufficient employment in defending them, and thus restraining them from ravaging Europe. But though these are topics connected with the progress of marine architecture and navigation, it is not intended to discuss them, or to attach any material importance to them.

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* Char., Vol. I. p. 327-8.

† Macph., Vol. I. p. 344.

The origin of the application of magnetic attraction to purposes of navigation is generally fixed at some period in the twelfth century; although Burchett and other authors have attempted to fix the invention of the mariner's compass at the beginning of the fourteenth century. But the writer of the article on "Magnetism" in the Encyclopædia Britannica, has shown that the loadstone was employed as a nautical guide as early, at least, as the latter part of the eleventh century. And he observes, "that the mariner's compass was known in the twelfth century, about the year 1150, is proved by notices of it in various authors." He then quotes the lines of Guyot de Provins, who he says was alive in 1181. These are lines of much interest, a literal translation of which was made for Dr. Larimer's "Concise Essay on Magnetism;" and afterwards given by Macpherson. "This (polar) star does not move. They (the seamen) have an art which cannot deceive, by virtue of the *manite*, an ill brownish stone to which iron spontaneously adheres. They search for the right point, and when they have touched a needle on it, and fixed it to a bit of straw, they lay it on water, and the straw keeps it afloat. Then the point infallibly turns towards the star; and when the night is dark and gloomy, and neither star nor moon is visible, they set a light beside the needle, and they can be assured that the star is opposite to the point, and thereby the mariner is directed in his course. This is an art which cannot deceive."*

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* History of Commerce, Vol. I. p. 362.

There is nothing, in this account given by the poet, inconsistent with the supposition of its having been previously known; as a distinct mention is made of it by an historical writer of the *eleventh* century. That in those ages in which science shone with a feeble light, a subject of which the investigation was so difficult, that to the present day it is imperfectly understood, should have remained for a lengthened period but little known, notwithstanding its surpassing utility to man, is more highly probable than that it should have been brought into general notice and regard shortly after its discovery. The absence of the means of rigid philosophical investigation appears to be sufficient to account for the slow progress that was made in the improvements of the compass, and in the confidence which was placed in it. And it is not improbable, that the addition of a circular card, by Flavio Gioia, of the city of Amalfi, in the beginning of the fourteenth century, may have led some authors to suppose that the polarity of the magnet was unknown till then; or that it had not been previously used as the mariner's guide. The card by which Gioia improved the use of the magnetic needle, contained, it is said, only eight lines; but even this addition was most material to its usefulness; and it pointed out the method by which the instrument could be rendered still more useful. The use of this instrument in its improved form, gradually inspired mariners with confidence; so that when they had tested the fidelity of their little guide, they could commit themselves to the trackless ocean without fear; and embark in the bold enterprises which, in a few ages, brought the inhabitants of the most distant lands into communication with each other, and rendered the productions of every region a common benefit to the world.

The reign of King John is not characterised by any thing great or noble; and yet in his reign, the British navy appears to have possessed considerable force; and to have acquired a permanence which it had not attained to before. The formation of the dockyard at Portsmouth contributed materially to this result. On one occasion, when John was about to cross over to Normandy, fourteen thousand seamen were collected to accompany him; and a few years afterwards, when the state of Ireland required some attention to restore order and tranquillity, the king sailed from Pembroke with a fleet of about 500 vessels. Something may likewise be inferred as to the naval power of England at this time, from the fact of the king's having ordered that all foreign vessels should pay respect to the maritime supremacy of England, by striking the flag to his ships; and declaring them to be lawful prizes, in case of their refusing to do so. During this reign was fought the first naval battle between England and France. Philip, king of France, after having prepared to invade England, and being forbidden by the pope's legate to do so, was annoyed at the prohibition, and invaded Flanders before disbanding his forces; the naval part of which consisted of seventeen hundred vessels, great and small. King John beheld with regret this violence offered to his ally, the Earl of Flanders; and sent over a considerable fleet, which surprised the French fleet lying at Danune, and gained a complete victory over it. Three hundred vessels loaded with provisions were sent to England; all the rest were destroyed, in the severe engagement which rendered the English conquerors, or were afterwards burnt.

Through all the troubles of this king, the navy remained firmly attached to him until the time of his death. After that event, when England was divided in opinion on the subject of the succession, and a foreign army was in the land, headed by a prince who, it had been vainly thought, would rescue England from oppression, the fleet of the Cinque Ports remained faithful to the heir; and under the orders of Hubert de Burgh who, as warden of the Cinque Ports, commanded Dover castle, on behalf of the young prince Henry, the fleet put to sea, and effectually prevented a considerable re-inforcement of French troops from landing in England. The stratagem by which they succeeded against a superior force was this: when the two fleets came near each other, the English vessels were driven with great violence against those of their enemies, which were to leeward of them; and to prevent the French from boarding them, the English laid a quantity of quick lime upon the decks of their vessels, which being blown by the wind over the vessels of the enemy, blinded the men, and compelled them to retire. This event, connected with others on shore, by which the power of the French was considerably diminished, and with the growing influence of the supporters of the young prince, led to the general acknowledgment of his claim to the throne of his father, on which he passed a long, but uninteresting reign, from the year 1216 to 1272.

But few events occurred relative to the naval establishment during this century, until nearly the close of it, when a private quarrel occurred, which at length led to most important consequences. Two vessels, one English, and the other Norman, being in want of fresh water, as they were off the coast of Bayonne, sent on shore at the same time for a supply. A quarrel arose between the men that were sent on this duty, and the Norman seamen killed one of the Englishmen, and pursued the other; who, however, escaped to the vessel to which he belonged. The Normans indulged an infuriated rage against the English. They took two other vessels; hanged the seamen belonging to them upon the yards of their vessels, with an equal number of dogs, in contempt of the English, and sailed for some time along the coast. The English who had escaped the fury of the Normans, related the circumstances of the affair, and the treatment their countrymen had received. Several English vessels were then fitted out, in which retaliation was practised in a similar manner. Piracy became general in the channel; whilst the kings, Edward the First of England, and Philip the Fourth of France, stood aloof from the quarrel until it had arisen to an alarming height. At length the whole naval force of the two countries was engaged to determine the contest, each country availing itself of the aid in vessels which their alliances could procure them. A general engagement ensued, in which the English were victorious; many of the enemy's ships being destroyed, and thousands of those who served in them slain: and the victors returned with their prizes, amounting to two hundred and forty sail of vessels.*

Although the Cinque Ports supplied the principal part of the vessels that were employed in war; yet as there were many other seaports in the kingdom, some of which carried on a considerable foreign commerce, there must have been some capable of supplying collectively a large amount of shipping. But it is probable that the ships belonging to these ports, were maintained expressly for commercial purposes; and were engaged in war only when the fleets of the Cinque Ports were insufficient for the expeditions to be undertaken. In the reign of Edward the First, in 1297, when the king invaded Flanders, with an army of fifty thousand men, he required the service of a considerable number of ships from Yarmouth, in connection with the fleets of the Cinque Ports. This association led to a disastrous result; for some disagreement arising between the mariners of the Cinque Ports and those of Yarmouth, thirty of the ships of Yarmouth were destroyed, with most of their men; whilst the expedition was unproductive of beneficial results.

Some time after this, a complaint was made by foreigners of the acts of piracy committed in the English seas; and the king of England was addressed by them as *lord of the sea,* to whom the sovereignty of the seas properly belonged, and requested to exercise his power in punishing the crimes which were committed within the bounds of his dominions. And accordingly the king and parliament appointed justices to determine the matters of complaint.

During this reign the first letters of marque, of which a notice has come under our observation, were granted in the year 1295, to a merchant of Bayonne against the Portuguese, by whom a cargo of fruit, which he was conveying from Spain and the north of Africa to England, had been seized. He was therefore authorised to make reprisals within five years, to such an extent as would indemnify himself for the loss and expense he had sustained by that seizure.†

In the thirteenth century, ships of considerable magnitude were built by the republic of Venice; and there is mention of one, called the Santa Maria, that measured about 125 feet in length; but whether by the keel, or on the deck does not appear. This ship, which was of extraordinary size, carried 110 seamen.‡ And Baptista Burgus mentions that two galleys fitted out at Genoa, sailed in search of western land in the Atlantic Ocean; but that they were never heard of afterwards. Spain adopted the practice of building large ships called carracks, far superior in magnitude to the vessels which were built in the more northern countries of Europe. It is not perhaps clear by what processes the Spaniards advanced to that superiority in ship-building; but before the middle of the fourteenth century, improvement seems to have become general in the most considerable maritime states in the Mediterranean. The Mahommedans possessed vessels of large burthen, of which, however, we know nothing of the construction. The people of Catalonia also had very large ships, some of which are said to have had two, and others three decks. The statement of their having had castles on their decks, seems to imply that the decks must have run the whole length of the ships. In the year 1334, four Catalonian ships, designed for both war and commerce, and carrying 1980 fighting men, besides seamen and women, merchandize and horses, were taken by ten Genoese galleys, after a battle of ten days.*

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* Hemingford.

† Fœdera, Vol. II., p. 681.

‡ Macpherson, Vol. I., p. 419.

In India, also, ship-building appears to have made considerable progress. The Indian ships employed in commerce were of large dimensions; and for the better accommodation of a number of merchants who might be trading to the same places, the ships were divided into several cabins by fixed, water-tight bulk-heads, one of these cabins being appropriated to the service of each merchant. These vessels were double-planked, and caulked with oakum; and the bottoms were covered with a sheathing of oil, lime, and hemp; this sheathing was renewed several times, as the state of the vessel might be considered to require it. They had four masts; carried from a hundred and fifty to three hundred men, and would convey a cargo of five or six thousand bags of pepper.

During the reign of Edward the Second, who ascended the throne in 1307, and was murdered at Berkeley Castle in 1327, the naval power of England seems to have declined to a most serious extent; whilst, for the most part, there was little to call for its exertion. At length, when the queen arrived from abroad to abet her husband's enemies, no opposition appears to have been offered to her by the navy; but whether from insufficiency of strength, or from a general defection in that establishment, it is perhaps not easy to determine.

Edward the Third, conceiving that he had a title to the throne of France, by virtue of his mother's descent, although the salique law excluded her from the throne, resolved to go over with an army and endeavour to acquire, by force, the possession of that which he had little reason to suppose would be conceded to his claim. In 1338, he therefore embarked his forces, for conveying which across the channel, a fleet of five hundred vessels had been provided. This armament was obtained with considerable exertion; for as the object of the expedition was one of great importance, so the king appears to have employed in it the greatest force he could command. He engaged the aid of all the confederates he could obtain. But before the army of Edward quitted the confines of the Netherlands, some of his allies withdrew from him, and the loss his army sustained by the several allies retiring, left him with an army of only forty-seven thousand men. Now, if Edward's own army consisted originally of forty thousand men, which it is highly probable it did not exceed, then the average number conveyed by each ship would be eighty men; whence it appears that the generality of these vessels were of very moderate dimensions. The greater part of this fleet was retained abroad; and the protection of the English shores was still further weakened by such other ships as could be fitted out, being sent to Scotland. In this unguarded state the French attacked several of the English sea-ports, and did extensive damage. To retaliate on them for this injury, the inhabitants of the Cinque Ports fitted out a number of small vessels, crossed the channel in hazy weather, attacked Boulogne by surprise, laid the lower town waste, destroyed the dock with the arsenal, four large ships, and thirty-nine galleys and smaller vessels.

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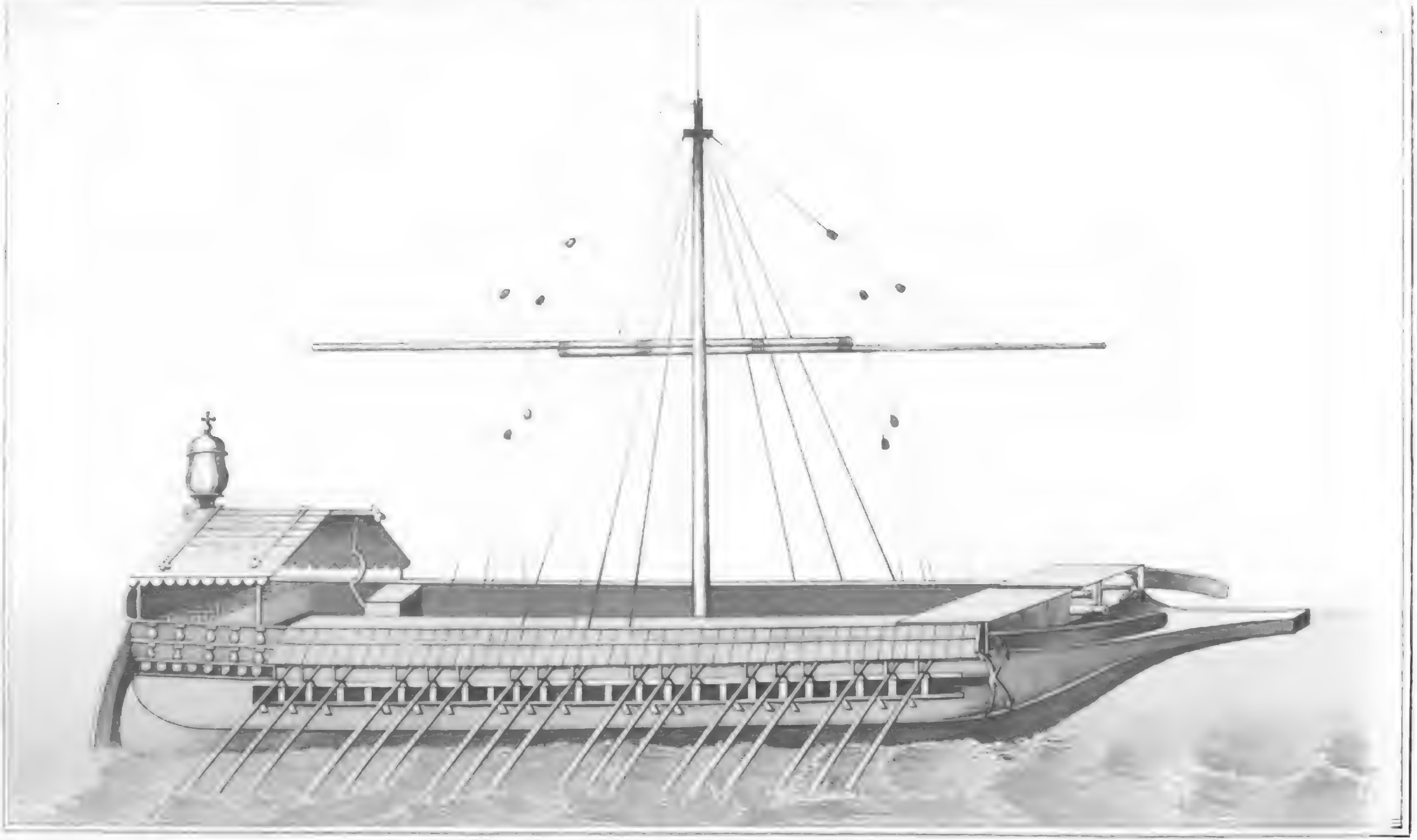
* Macpherson, Vol. I., p. 507.

Edward having been obliged to return to England for a fresh supply of means for carrying on the war, prepared to renew his expedition in the summer of 1340. King Philip the Sixth of France had, in the mean time, collected a large fleet in the harbour of Sluys to oppose the English and prevent their landing. Intelligence of this preparation reached Edward when he was on the point of embarking, and he was assured of the necessity of increasing his armament. Within ten days after the order had been issued for a further supply of ships and men, the supply exceeded the number required. When the English arrived off Sluys they were met by the French, who brought against them 400 vessels, manned, on an average, with one hundred men each; whilst the English had only 240 vessels. They fought, however, with deliberate and steady force, having gained the wind of their enemies. They were at length also reinforced by the Flemings, who brought a considerable force to aid the English. The French had suffered severely from the commencement, by the English cross-bows; and when the contending vessels grappled, the fury of the engagement did not slacken; but when the Flemings joined their confederates, the result of the contest was decidedly in favour of the English. The French were finally beaten, with a loss, it is said, of more than three-fourths of their number, many of whom leaped into the sea, and two hundred and thirty of their ships were taken. The loss of the English appears to have been very moderate, although some of their vessels were sunk by the stones which were thrown into them by the French, who had constructed machines on board of their vessels for this purpose. The accounts of this battle contain the first mention of ships in the English service being distinguished by names, with the names also of the captains commanding some of them.

From this time the war was carried on by land during a considerable

A GALLEY, BUILT IN THE 14th CENTURY.



period. A truce was afterwards granted for one year; the war was then renewed, and a truce for three years agreed to in 1343. When this term had nearly expired, the king caused a fleet to be provided, of about a thousand vessels, of all sizes, to convey his army across to Normandy. The result to which this invasion led was the victory of the English at Crecy. Having obtained so important a triumph, Edward conceived it expedient to obtain a more convenient inlet into France; and with this view he directed his operations against Calais, which was taken in August, in the year 1347.

The fleet employed in the blockade of this place consisted of 738 vessels, carrying 14,956 mariners; being, on an average, about twenty men to each. Seven hundred of these vessels belonged to England; the other thirty-eight were foreign vessels. Fifteen of the latter, and 439 mariners, were supplied from Bayonne, being about twenty-nine men to each ship; seven vessels and 184 men from Spain, which is twenty-six men to each vessel; one from Ireland, carrying twenty-five men; and fourteen from Flanders, with 133 men, being scarcely ten men to each vessel. Twenty-five of the British ships were called the king's own ships, manned with 419 mariners, being, on an average, something under seventeen men to each. (*Plate* 8.)

After the taking of Calais, another truce was agreed to, which lasted till 1355; and in 1356 the war was renewed. The battle of Poictiers appeared to have advanced the objects of the English, for the French king was taken and brought to England. But as the French nation refused to submit to the terms which, under these circumstances, it was attempted to impose upon them, Edward again invaded France, having collected a fleet of about eleven hundred vessels to convey his army from Sandwich to Calais. Yet, instead of having made any advance towards attaining the crown of France by the long war, he saw that object, after the present campaign, to be unattainable, and entered into a treaty before leaving the country, by which he renounced all claim to it.

Subsequently to the seige of Calais, the use of galleys was generally discontinued in war, except in the Mediterranean; and galleons were introduced into the English service about the middle of the fourteenth century.

The introduction of this description of vessels into the English service, it is highly probable, resulted from the capture of a number of Spanish galleons, in 1350. This event occurred off Winchelsea, and was occasioned by the seizure of some English vessels in the channel, by a fleet of galleons, which were bound to Flanders. On their passage thither, the Spaniards first plundered of their merchandise, and then sank the English vessels which they met. On intelligence of this reaching England, a duty was levied to defray the expense of fitting out a fleet to meet the Spaniards on their return. The king, and a number of his most considerable subjects, went on board of his ships to add dignity to the enterprise. The fleet consisted of only fifty; that of the enemy consisted of forty-four galleons, which, it is said, appeared like floating castles in comparison to the English vessels. The latter, however, gained a complete victory, after a hard-fought battle, capturing several carracks* richly laden with merchandise; whilst the darkness of the night enabled the others to escape to the opposite coast.

Notwithstanding the large demands on the seaports in general for shipping, during the progress of the war with France, and the large amounts they were able to supply, the maritime interests of the country appear to have languished during the latter part of the reign of Edward the Third. This may have been, to some extent, the consequence of the great demands made for the supply of ships having drawn the service of them from the commercial pursuits, by which alone they could generally flourish.

The improvements which were made in the building of ships in the Mediterranean, extended their influence into the more northern countries of Europe, especially the Hanse Towns; the commercial people of which were ready to imitate what was valuable and useful to themselves, in the peculiarities of the ships built in the south of Europe. And soon after this period, ships of much larger size were built.

During the reign of Richard the Second, the naval power appears to have been in an extremely inefficient state. The protection of the coast was neglected, and the French invaded the shores of England without, as it appears, any fleet to oppose them. In the summer of 1377, they appeared off the coast with a fleet of fifty vessels, from which they landed, and burnt the town of Rye. A short time after this event they appeared again, and landed at several places along the southern coast of England, and plundered and destroyed several of the most important towns on the coast. They were repulsed at Southampton; and when they landed shortly afterwards in Sussex, they were ineffectually encountered at Lewes. When, afterwards, a fleet was fitted out to resent these injuries, the ships were compelled, by adverse winds, to return to port without having accomplished any service.

After the lapse of several years, the war with France was resumed, under Richard the Second. Since Calais had been in the hands of the English, they were able to land an army at pleasure, and to take the most favourable circumstances for conducting all their operations in the field. In the year 1380, a small army was sent over to France, where military operations were carried on to a considerable extent. But in the mean time, the shores of England were left unprotected, or but inadequately guarded; and the French sent over a number of vessels which, sailing along the coast of Kent, and up the river Thames, plundered the country and burnt the town of

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* Burchett, p. 333.—Macpherson, Vol. I. p. 541, says the English took twenty-four carracks; and that some authors state the number at twenty-six.

Gravesend, whilst the resources of the nation were exhausted for other purposes than the protection of its interests. In 1382 a large reinforcement was sent over, amounting to nearly sixty thousand men; and the fleet which conveyed them across the channel was afterwards employed in ravaging the French coast. But no advantages appear to have been gained by these operations. The French seem rather to have been roused to energy, and to have been provoked to aggression. As success had attended a bold predatory attack on the shores of England, so that sort of expedition was repeated. Alarmed at the consequences of these incursions upon the British shores, the inhabitants of Portsmouth, at their own expense, fitted out a squadron about equal to that of the enemy, with which they attacked and captured the whole of the French ships. The project of invading England on a large scale was afterwards formed; and it is said that nearly thirteen hundred vessels were fitted out for this service, which, after considerable delay, was ultimately abandoned.

The close of the fourteenth century was a period of violence and disorder in England. The disaffection which the English felt towards the king, led to his being dethroned and put to death, and the throne became occupied by Henry the Fourth, of the House of Lancaster. He was crowned on the 13th of October, 1399. Few events of any interest relating to the navy appear to have occurred about this time; for the nation was agitated violently by internal commotions. The Welsh, under Owen Glendower, revolted; and the French taking advantage of the unsettled state of England, sent over an army of twelve thousand men, in 140 vessels, which, with the seamen, did not in all probability exceed on an average, a hundred and five or a hundred and ten men to each vessel. Whilst the French vessels were lying at Milford Haven, a fleet was fitted out by the Cinque Ports, and proceeded under the command of Lord Berkley, to attack them. Several of the French vessels were destroyed; and the others escaped to their own coast. Afterwards, when the French troops were desirous of being sent home, vessels sufficient for this purpose were supplied by the different ports of Wales; a fact which shows that though the English kings had formerly evinced a jealousy about these ports, the possession of them had been retained to a great extent, or recovered by the natives.

That the maritime power of England was in a very low condition, appears evident from the general events that occurred about this time, in which its interests were concerned. It is true that a fleet was sent over ,with orders to disturb the coasts of France and Flanders; and that on entering the harbour of Sluys, they took three large Genoese merchantmen, and landed upon several parts of the coast, destroying a considerable number of towns which they had first plundered; and then returned with a large accumulation of spoil. But notwithstanding this, their own shores were open to the assaults of the enemy, whilst a desultory kind of warfare was carried on between the English and French, more in the character of general piracy than of national war. At one time the king himself narrowly escaped falling into the hands of some French privateers; for as he was passing from Queenborough to the coast of Essex in the summer of 1407, with only five ships, his little squadron was attacked by some French privateers, when four of the ships were taken and carried off; and that only escaped which was conveying the king. This narrow escape served to show the importance of paying greater attention to the navy than it had received for some years previously; and led to the fitting out of a strong squadron in the following year. The command of this was given to the Earl of Kent, and the object was to destroy the French privateers that infested the channel. He therefore, having gained sight of them, pursued them to their rendezvous, where he effectually accomplished the end he had in view. One other naval expedition is mentioned in this reign; this was the sending of ten sail against Scotland; by these considerable damage was done to the Scotch on shore; and fourteen vessels were captured and brought away, besides others which were burnt.

Henry the Fourth died on the 20th of March, 1413; and was succeeded by his son, Henry the Fifth. This prince revived the claim to the crown of France; and taking advantage of the distractions which prevailed in that country, he prepared to renew the operations for the conquest of it. He assembled at Southampton and other ports, a fleet of 1500 vessels, some of which he had hired from Holland and Zealand. To collect the requisite fleet, the king ordered that all the vessels in England of twenty tons burthen and upwards should be taken into his service.* The army which this large fleet was required to convey, amounted to 30,000, or according to other authority, 50,000 men. From this mention of tonnage, and the number of vessels required on this occasion, it appears that little benefit had resulted to ship-building, from the introduction of carracks into the English service. The northern kingdoms of Europe appear to have carried out improvements with energy; for there is mention made of a Prussian ship of 300 tons bringing corn to Berwick-upon-Tweed, in 1409.* The results of this invasion of France were the taking of Harfleur, in which a garrison was placed; and the battle of Agincourt, in which one of the most remarkable victories was gained by the English, on the 25th of October, 1415.

The French, soon after this, engaged a number of ships from Spain and Genoa, being greatly superior to their own, with a view to ravage the southern coast of England. In attempting to do so, however, they were repulsed. They then laid seige to Harfleur with all the ships that could be brought together for this service, at the same time that the town was strongly besieged by land; relief was at length introduced into the town, four hundred vessels having been fitted out, and an army of twenty thousand men embarked. The Duke of Bedford, who commanded the fleet, first attacked the besieging fleet, and gained a complete victory over it, taking and destroying five hundred sail; the Earl of Huntingdon also gained a great victory over a considerable fleet of French and Genoese ships, which was superior to that which he commanded. A large amount of money on board of some of the ships considerably enhanced the value of the prizes.

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* Macpherson, Vol. I., p. 628.

* Hakluyt, Vol. I., p. 181.

Henry, having returned to England after the battle of Agincourt, prepared in 1417 to renew his operations in France. Fifteen hundred vessels were assembled at Dover to convey his army of 25,000 troops into Normandy. It is also said that about this time, the king having observed the superiority of the Castilian and Genoese ships, caused some very large vessels, called dromons, to be built at Southampton; "such," says an old writer, "as were never seen in the world before, three of which had the names of the *Trinity*, the *Grace de Dieu*, and the *Holy Ghost*. But the principal vessels of the whole fleet, wherewith he made his second invasion of France, were two large ships, most magnificently fitted up. One of them, called the *King's Chamber*, in which he embarked himself, carried a sail of purple silk, whereon the arms of England and France were embroidered; and the other, called the *King's Hall*, was also very sumptuously adorned."* It is, however, probable that the *King's Chamber* and the *King's Hall* were two of the ships previously mentioned. The fleet which was employed in this expedition appears to have been required only for the conveyance of his troops; as a few only of the ships were retained abroad, for the conveyance of artillery, the rest being sent home.

After gaining important successes in France, and obtaining a treaty in which his title to the succession to the throne of France was acknowledged, he returned to England early in the year 1421: yet he invaded France again the next year, and gained some advantages; but being taken ill in the midst of his military operations, he was conveyed to Vincennes, where he died on the 31st of August, 1422.

Henry the Sixth was proclaimed at about the age of nine months. The government during the minority had been arranged by the late king, in the closing hours of his life; but from the period of his death, the possessions in France, which had been acquired in the long war, were gradually lost, notwithstanding all the ability and care of the Duke of Bedford. Nor was the progress of the French arms arrested until, in 1453, the English were driven out of the last place they occupied in France, with the exception of Calais, which was retained more than a century longer.

The wars of the Roses, which went far to destroy all the prosperity of England during the latter years of this reign, confined the operations of the English within their own country; and there was little occasion for a navy: still a navy was maintained, and the Earl of Warwick was made admiral of

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* Macpherson, Vol. I., pp. 631-2.

England and governor of Calais, where the principal naval armament of England was kept. The power which the Earl derived from these appointments enabled him to do much for the interests of England; it enabled him to prevent the introduction of foreign armies, and thus to leave the determination of the contest to the proper resources of the nation. As the Earl was engaged in the interests of the House of York, the employment of the fleet was of course adverse to the cause of King Henry. In the year 1458, an English squadron was cruising in the channel, and fell in with a fleet of Spanish ships, which were attacked, and six of them taken after a severe engagement; and twenty-six others were either sunk or driven ashore. Some time after this, the Earl himself, in the command of a squadron of fourteen vessels, attacked three large Genoese and two large Spanish carracks; the engagement lasted two days: three of them were captured, but the two others escaped.* In order to recover the naval power to the service of the king, the queen issued an order for those ships which the Earl had not carried off with him, to be fitted out at Sandwich, and to proceed to Calais, to deprive the earl of his command. Hence it appears, that the Cinque Ports were still attached to the interests of the king. Intelligence of the preparations against the earl having been communicated to him, he sent over a squadron, which attacked the ships in the port under the command of Lord Rivers, who was conducted with all his fleet over to Calais. Another attempt was made to recover the fleet from the Earl, by fitting out another fleet under Sir Simon Montford, lord warden of the Cinque Ports; but the earl crossing over suddenly, surprised the lord warden, took the whole of his ships, plundered the town of Sandwich, and then returned to Calais.†

Although there were some instances of large ships being in the possession of the English about the middle of the fifteenth century, yet it appears to have been an extraordinary circumstance for ships of very large dimensions to be built in England; and it is highly probable that the ships of unusually large dimensions were of either Spanish or Genoese build. The encouragement given by an exemption from customary imposts, on the building of a large carrack, called the "Grace Dieu," by John Tavernor, of Hull, indicates that the building of such a ship was of unusual occurrence. The large ships of 400, 500, and 900 tons burthen which the king took from Canyngs, of Bristol, were most likely of foreign construction, and had been brought to England either from the south of Europe or from the Baltic: for the northern nations of Europe then produced ships of considerable burthen; as there is also mention made of one of nearly a thousand tons burthen being sent by Charles, king of Sweden, in 1455, with a request that she might be permitted to enter the ports of England, for the purposes of commerce, subject to the payment of the usual duties. But the state of England was very unfavourable to the advance of navigation; for commerce, which supplied the greatest impulse to it, was subject to many interruptions and imposts, so that the results of its undertakings were rendered very precarious. And hence, whilst the English had the example of their commercial neighbours in the building of large ships, and their own experience of the superior usefulness of vessels of such dimensions, they appear to have made but little advance in the production of such ships themselves.

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* Burchett, p. 334, says the carracks were all taken.

† Ibid, p. 335.

During the civil wars of this period, there appeared the most unequivocal evidence of the connection between the possession of the navy and the possession of the throne. Twice the Earl of Warwick interfered; and by each interference determined who should be king. Nor was it less evident in that event which brought the House of Tudor to the throne, that dominion in the channel was most materially connected with the safe possession of the kingdom. Richard the Third reached the throne, and so far subdued his enemies, that the country was quiet; and it might have remained so in his hands, if he had kept the English channel guarded with due care. He had a fleet; and that fleet might have saved him if it had been employed with vigour and fidelity: the little fleet of Henry, Earl of Richmond, however, arrived at the shores of England, and his friends united to support him, which they did effectually, by conducting him to the throne, after the victory his troops had gained in the battle of Bosworth field, in August, 1485.

Portugal, though one of the smallest kingdoms of Europe, but necessarily a maritime state, began, about the beginning of the fifteenth century, to direct her attention more particularly to maritime pursuits, as the only obvious means of conducting her to importance and fame as a civilized country. Accordingly, she began to take the lead in voyages of discovery, that she might increase her power, extend her commerce, rise to greater prosperity, and acquire an influence in the earth as the reward of her exertions. Every voyage which the Portuguese performed was important; for, though the immediate results of some of the voyages may not have been very material in themselves; yet every great effort appears to have encouraged a repetition of enterprise, until extensive settlements in Africa, India, and America, rewarded their perseverance.

A part of Portugal having been erected into a kingdom, the king exerted his utmost power to enlarge his territory. This he did by colonizing such places as his fleets discovered, and were able to bring under subjection. In 1410 a fleet was fitted out, under Henry, the son of John the First; and the voyage performed by this fleet led to the discovery of Madeira. Successive voyages extended valuable discoveries along the coast of Africa, which they seem to have aimed at, keeping it constantly in sight: Cape Non was reached, another expedition passed it; and at length, in the reign of John the Second, the Portuguese discovered and passed the Cape of Good Hope, in 1497. This great effort was accomplished by Vasco de Gama, who then saw with satisfaction the route opened to India. Passing along the eastern coast of Africa, and crossing thence to India, the Portuguese had the choice of making settlements on the coasts and islands, of which the native wealth and commercial advantages appeared to be the most inviting. Sofala, with its rich mines; Mosambique, with its wealth and commercial advantages; and India, with the ample productions of its soil, all contributed to reward the enterprise of the Portuguese by an influx of wealth into their country. Another voyage accidentally led to a new discovery; a fleet of thirteen ships having been sent out on a voyage to Malabar, Cabral, who had charge of the expedition, was driven by adverse winds towards the west, and discovered the coast of Brazil, of which he took possession, in the name of his sovereign, to whom he sent home intelligence of his success, and proceeded on his voyage; and having accomplished this, he returned to Portugal.

The early efforts of Portuguese navigation were preliminary to those of greater enterprise which distinguished the close of the fifteenth century; and the results of them prepared the way, in some measure, for the bolder project which Columbus formed. Christopher Columbus was a native of Genoa; in his youth he had been well instructed in those branches of knowledge which were immediately conducive to his future eminence; and he went to sea at the age of about fourteen years. In the year 1467 he made a voyage into the north sea to ascertain whether Iceland was inhabited; and, advancing a hundred leagues beyond that island, he was surprised at finding his progress still unobstructed by ice. After this voyage he settled in Portugal, where travellers and navigators generally received the greatest encouragement. During the time he spent in that country, his occupation was principally that of making maps and charts; and sometimes he was employed in making short voyages to the islands in the Atlantic. Having at length matured his plan for his western discoveries, he at first offered his services to his fellow citizens of Genoa, and they were declined. About the year 1482, he offered to take the command of an expedition for the discovery of lands to the west, for the service of Portugal. His ideas of the remote lands appear not to have been entertained with much confidence; the courtiers, however, gained from him much information respecting the course he intended to pursue; and then sent out privately a vessel with instructions to the pilots to observe the route that had been pointed out by Columbus on the charts. As these pilots had little confidence in the statements which had been made to them, so they were destitute of the zeal which was requisite to success. They returned and made an unfavourable report; and Columbus, offended at the manner in which he had been treated, left the country.

Columbus was too confident of the correctness of his theory to abandon his scheme; and, accordingly, he sent his brother Bartholomew to England, to state his views with respect to the sphericity of the earth, and to offer his services to Henry the Seventh for conducting a voyage of discovery; at the same time he went into Spain, and spent eight years in endeavouring to get his proposals accepted in the service of that country. Here again the conduct of those with whom he had to negociate, determined him to quit the country in disgust; when, by the liberal offer of the queen he was recalled, and his services engaged on the 17th of April, 1492. Bartholomew had met with the greatest difficulty in accomplishing the object of his mission in England, although the theory on which his confidence was grounded, was not cavilled at as it was on the continent; but, even when the matter was brought fairly under the notice of the king, he was too much engaged in a war for the reduction of Scotland, to give to the proposal the attention it deserved. And he delayed so long before he would accept the offer of Bartholomew on behalf of Christopher Columbus, that that navigator had been fully engaged in the service of Spain, and had made his first discovery on behalf of king Ferdinand before he knew the result of his brother's negociation; and hence, all that was valuable in the services of such a man, and all the advantages that resulted from his genius, intelligence, zeal, and enterprise, were lost to England.

Columbus having been engaged by the king and queen of Spain, preparations were made during the summer of 1492 for the expedition; and on the 3rd of August he left Spain with three vessels, two of which were no better than vessels which are now commonly used in the coasting trade. A hundred and twenty men were all that he required to serve in his squadron; and even this small number could not be prevailed on to enter voluntarily into the service; recourse was therefore had to impressment to complete it. He proceeded to the Canary Islands, where the vessels were re-fitted; and he sailed thence, on the 6th of September, in a westerly course. The fears of the crew were so strong during the voyage, that it required all the ingenuity of a mind fertile in expedients to allay them, and to prevail on the men to continue the voyage. A variety of indications of the proximity of land had appeared previously to the evening of the 11th of October, when about ten o'clock, a light was seen by Columbus, and pointed out by him to one or two of his attendants: this light appeared and disappeared several times, and hope was raised to the highest pitch of confidence. About two o'clock on the morning of the 12th of October, land was discovered from the pinta; and notice of it was given by the firing of guns: it was an island; and when Columbus landed and took possession of it in the name of the king of Spain, he gave to it the name of San Salvador. Several other islands were afterwards discovered; but the continent of America was not discovered during this voyage. Columbus spent nearly three months amongst those islands; and then, sailing again for Europe, he arrived in Spain, on the 15th of March, 1493.

The fame of Columbus had no sooner spread over Europe, than an intense desire was felt to know more of those remote lands; and to share the advantages of the extensive range which was presented for commercial enterprise. In September, 1493, Columbus sailed again with seventeen vessels, and 1500 men; and as in this voyage, he continued to make further discoveries of islands, he did not return till the summer of 1496. In a subsequent expedition which he conducted in 1498, he discovered, together with other islands, the main-land of South America; but, whilst he was prosecuting his enterprise in the new world, he was arrested, by order of the king, and conducted back to Spain in chains.

The English were roused by the events that interested all Europe, to a consideration of the honour, as well as the advantage, which had been acquired by foreigners who had been foremost in these adventures: more particularly was John Cabot, a Venetian merchant of great wealth and superior intelligence, who was at that time residing at Bristol with his three sons. Of these, Sebastian, the second, who is best known in history, was then, in 1496, nineteen years old; he had been early trained to the study of geography, navigation, and astronomy, in which he made considerable attainments: John Cabot offered his services to the king, to conduct a voyage of discovery with the view of finding a north-west passage to India, and Henry readily accepted his proposal, granting him a charter for that purpose, dated the 5th of March, 1496. About a year after the granting of this charter, Sebastian Cabot sailed (probably with his father) in a ship named the *Matthew*, which was fitted out at Bristol, accompanied by three or four other vessels fitted out principally by London merchants, and freighted with such commodities as were deemed suitable to barter with uncivilized people. On the 24th day of June, 1497, in about fifty-six degrees of north latitude, land was discovered. Very little is known of this voyage beyond the fact of its being associated with the discovery of land which was supposed to be an island. The second charter was granted to Cabot, on the 3rd of February, 1498, and the design of the voyage undertaken by virtue of this charter, seems to have been to realize the benefits which the former discovery promised; Cabot was authorised to take six ships out of any haven in the kingdom, of the burthen of 200 tons and under. A third voyage was made to the gulf of Mexico, in 1499, when the vessels coasted along part of the isthmus of Darien; but very little is, however, known of these expeditions beyond the fact of their having been performed.

In the year 1502, king Henry granted a charter to Hugh Elliot and others, licensing them to sail "with such ships and mariners as they should judge proper," into all parts of the eastern, southern, western and northern seas, in order to discover any parts which had not then been discovered, and brought under the obedience of any of his confederate friends. No pecuniary assistance was supplied to these people, whose own resources were insufficient to the accomplishment of any great enterprise; and they returned with no better success than Cabot had realized.

In the year 1499, Americus Vesputius, a Florentine navigator, in the service of the king of Spain, made some discoveries on the coast of South America. Columbus having at that time some powerful enemies at court, the honour of having discovered the continent was given to his rival, after whom the whole country was named.

These adventures in navigation all pointed out the importance of improvements in marine architecture; for though ships of considerable burthen were not now uncommon, yet they were far from being numerous; and the voyages which distinguished this era were for the most part performed in vessels of very moderate, and inconveniently small dimensions, and frail construction. An impulse was given by these events to ship-building, the force of which has never been wholly lost; and successive alterations and improvements have been introduced with various degrees of success.

The Venetians and Genoese appear to have kept generally in advance of the other nations in the building of ships. These commercial states, after peace had been restored between them, made great progress in marine architecture; their carracks and galleases were of peculiar construction; some built at Genoa as early as about the year 1452, are said to have measured from 1500 to 2000 tons burthen. Towards the close of the fifteenth century, great improvements were made in the construction of ships, particularly in the Mediterranean, in vessels which became distinguished as ships of war. Shortly after this, the use of cannon on different decks, by means of port-holes, which had their origin about this time, added materially to the force of ships of war; the port-holes were at first circular; and so small, that there was scarcely sufficient space for the gun to be trained in the least degree; but the size of the ports was afterwards increased so much as to obviate in a great measure this inconvenience. In order to adapt the construction of ships to this innovation it was necessary to alter the form of their sides; as the falling out of the sides of the old galleys was ill suited to the carrying of guns; for this purpose, the Venetians gave to the sides of their ships a great *tumbling-home*. This alteration was soon imitated by other states; and particularly by the Spaniards; and it was carried to an extreme which was soon shown to be inconvenient, but which growing experience gradually corrected; and the more moderate tumbling-home, similar to that of some of the old French and Spanish ships, was introduced. Their masts, which were five in number, continued the same till nearly the end of the reign of Charles the First; and, in conformity to the most ancient usage, they were without division. Descharge, a French builder at Brest, is said to have been the inventor of port-holes; and they were used in England in the early part of the sixteenth century.

The galley, galleon, and galleas being names commonly given to vessels of war in the Mediterranean, during the fifteenth century, it may be proper to show in what their difference consisted. Both the galleon and the galleas were similar in construction to the galley; the galleon, from having additional height of top-side, was considerably broader, and something shorter than the galley. The galleons were vessels of war, carrying guns; and were generally placed in the front of the line of galleys: they appear to have carried guns on the broadside between the oars, of which they carried three banks or tiers; the vessels of this description were likewise furnished with guns at the head and stern, as well as the galley, but with a greater number and of large calibre. It is recorded, that at the battle of Lepanto, which was fought on the 7th of October, 1571, some of them carried eight demi-cannon (*Plate* 9,) nearly equal to our thirty-two pounders: this classs of vessels spread over the Mediterranean; and, in 1588, there were four of them in the Spanish service, each of which is said to have carried fifty guns.

As the use of the galleon increased, the use of oars was, of course, superseded by that of sails; this alteration appears to have taken place to a considerable extent in the vessels belonging to Venice and Genoa. The galleon necessarily contained such additional breadth and height as qualified it for the use of cannon (*Plate* 10, *Fig.* 1,) which by that time had become an important part of naval artillery; but the structure of the galleon was often too unwieldy for management; and the Spaniards, who aimed at superiority in naval architecture, still retained much of the peculiarities of the galley in some of their ships; as may be observed by the engraving of one of their ships, which was destroyed with the Armada. (*Plate* 10, *Fig.* 2.)

Previously to the reign of Henry the Seventh, it had been common for the kings of England to rely, often entirely, and always to a great extent, upon the Cinque Ports for the supply of shipping in times of war; but Henry's policy, advancing with obvious necessity, led to the establishment of a royal navy, the foundation of which was laid in the building of the *Great Harry* (*Plate* 11,) at an expense of fourteen or fifteen thousand pounds; this ship was accidentally burnt at Woolwich in the year 1553.

There is an account of the building of a large ship called the *Great Michael*, in Scotland, in the year 1506. She was 240 feet in length, and 36 feet wide within the sides; and ten feet thick in the wall and boards; she was the largest ship that had ever sailed from England or France;* probably she was too weak in construction and combination to sustain so immense a mass of material, as she was lost on her way to France in 1512.

In the report made in 1805 by the commissioners for revising the civil affairs of the navy, it is stated that the permanent naval force during this reign consisted of only fifty-seven vessels, each carrying twenty-one men and a boy. Henry died in April, 1509; and was succeeded by his son Henry the Eighth.

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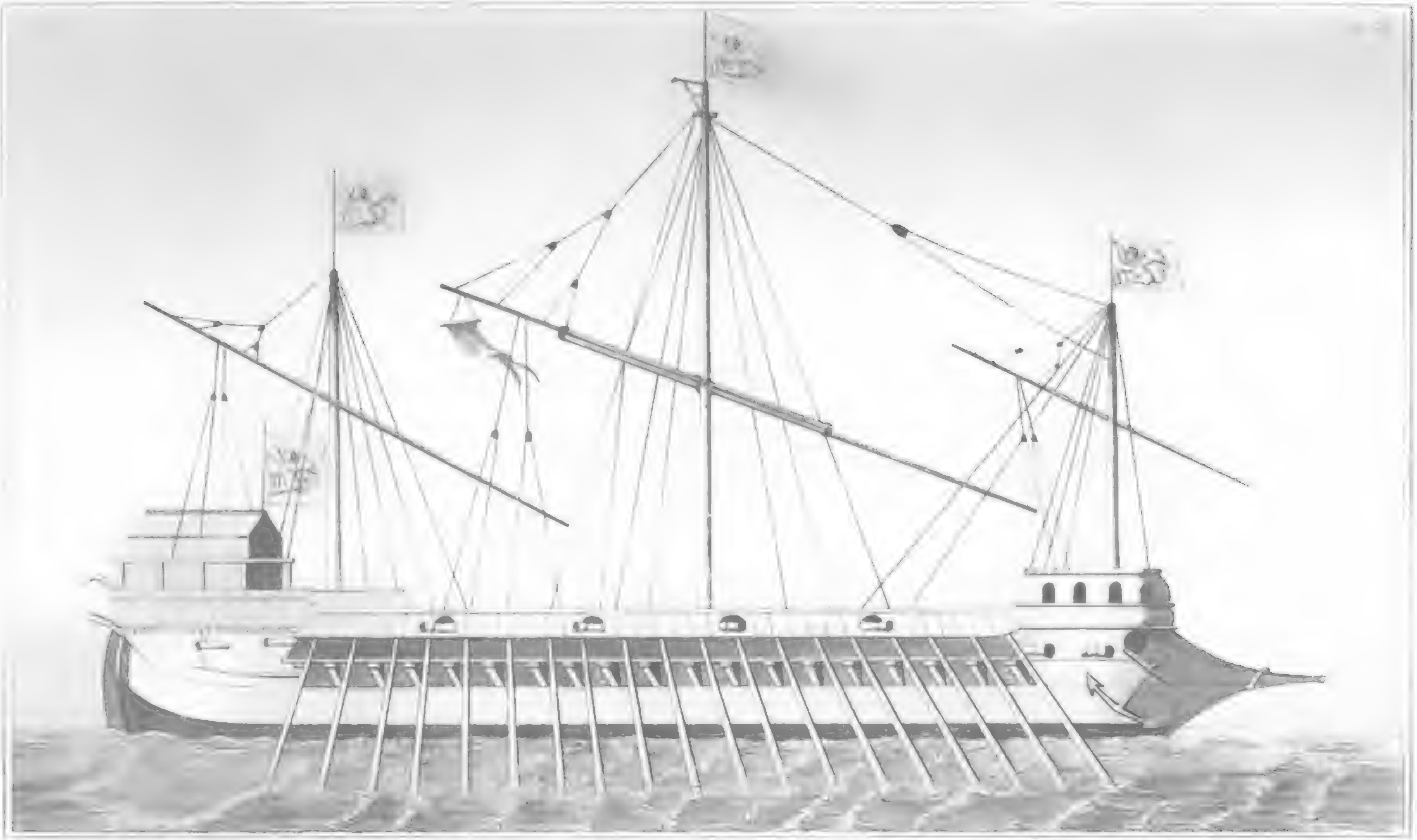
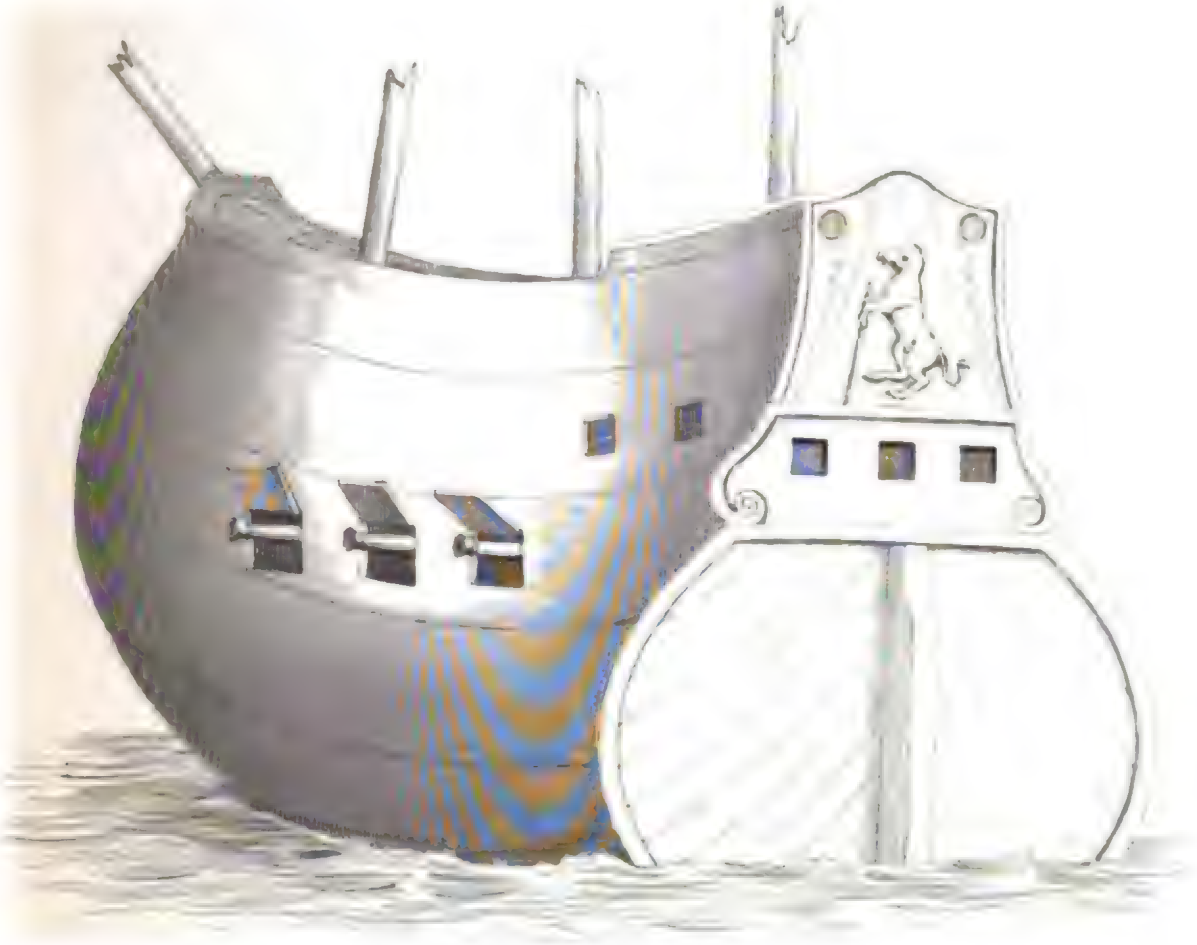
* Charnock, Vol. I. pp. 359-60.

A VENETIAN GALLEAS, AT THE BATTLE OF LEPANTO.



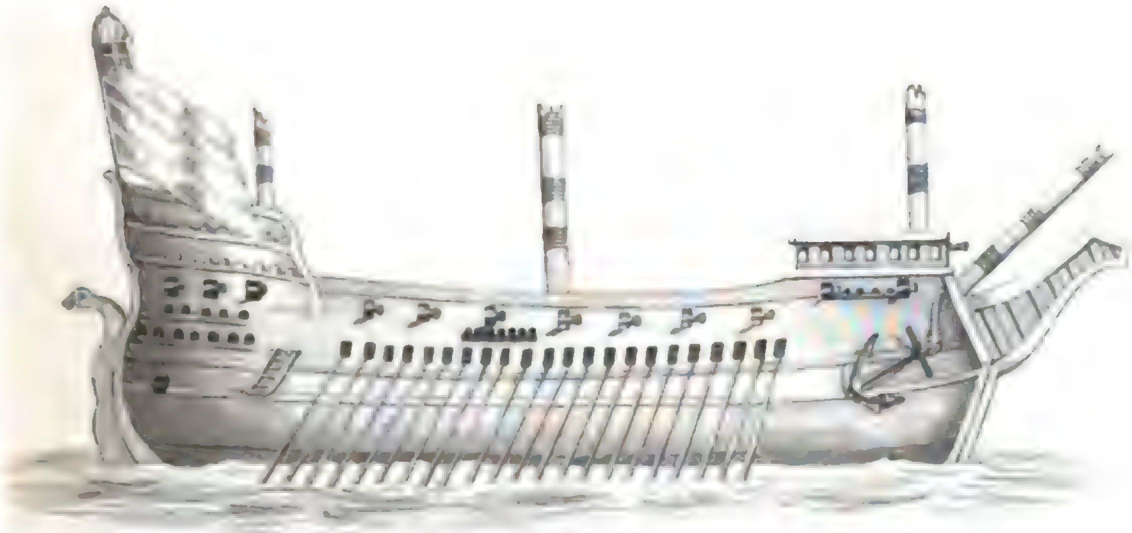
A VENETIAN GALLEON IN 1564.

FIG 1.

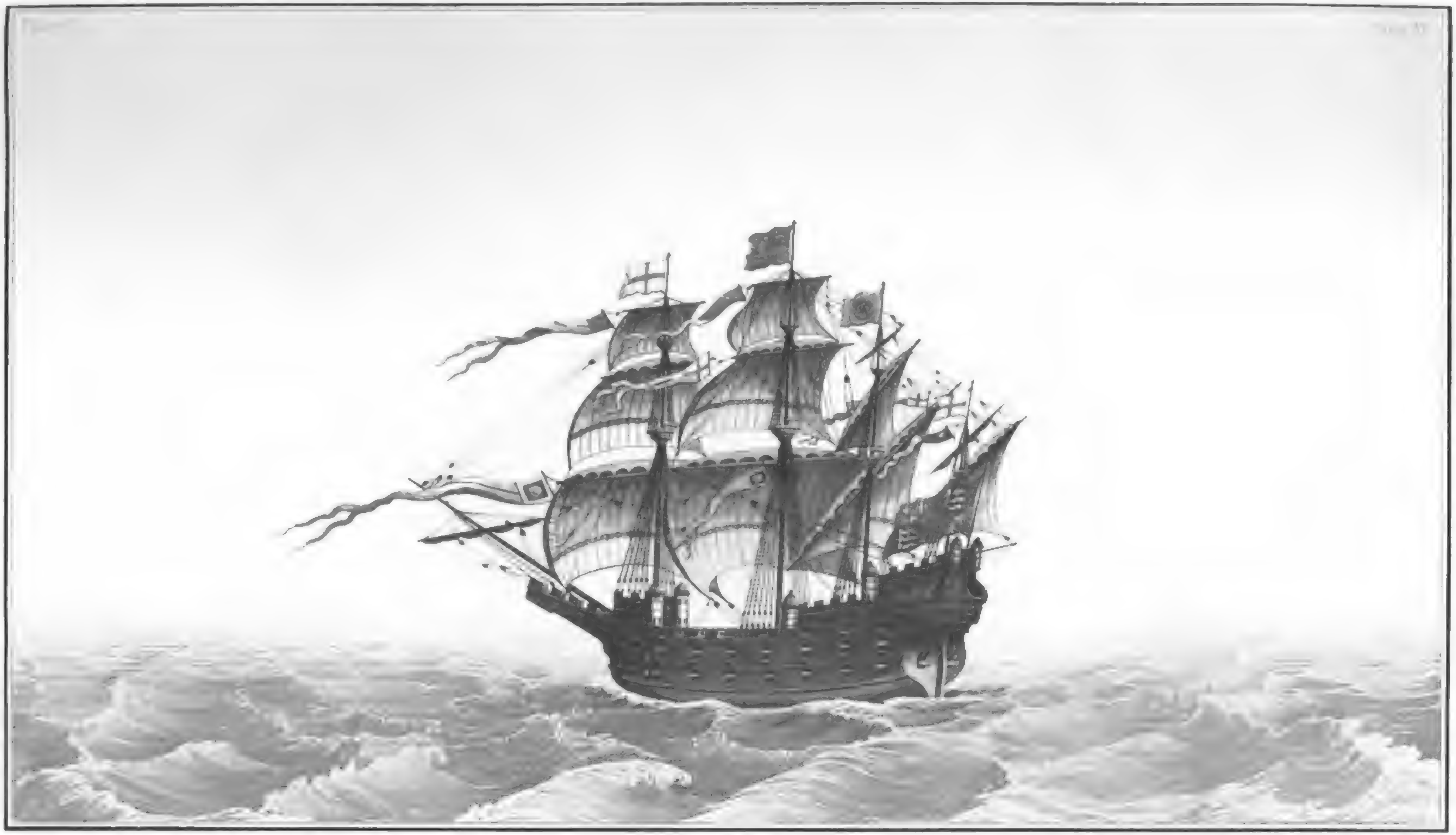


A SHIP IN THE SPANISH ARMADA.

FIG 2.



THE GREAT HARRY.



This monarch, in the early part of his reign, showed a disposition to employ and to improve the navy of England. Whether the mere love of display might be the ruling passion, or whether a true regard for the interests of the nation prompted him to raise the navy to a state superior to what it had previously been, it is not necessary to inquire. In the year 1511, when the king of Arragon applied to Henry for succour in his contest against the Moors, the king sent over four "royal ships," accompanied with a small land force; these were not, however, employed; and on being dismissed, they were presented with a small acknowledgment of the favour the king had shown in sending them.

Henry also revived the project for invading France, to recover the provinces which the English had formerly conquered, but which had been subsequently lost; he therefore immediately caused new ships to be built, and the old ships to be rigged; and abundance of other preparations to be made for commencing the war with vigour. But a war with France was not so national an object as it had formerly been; it was considered that the material alteration in the manner of fighting had greatly diminished the chances of success, by raising the French in military power. The first fleet of twenty ships which was fitted out, was employed under the command of Sir Thomas Howard, for the conveyance of an army of ten thousand men, which were not, however, employed in any way towards the recovery of the French provinces; but the fleet under Sir Edward Howard, ravaged the coast of Brittany, reducing the inhabitants to great distress; and led them to apply to the English Admiral for a cessation of hostilities.

These transactions led to considerable preparations on the part of the French; and in the next year, 1512, they fitted out a fleet of thirty-nine sail in Brest harbour. King Henry likewise then fitted out all the remaining ships and galleys that he had; and these were ordered to join the principal fleet. Before, however, they proceeded to sea, the king reviewed them at Portsmouth; they were "twenty-five ships of great burthen;" and when they had joined the principal fleet, the whole amounted to forty-five sail. This fleet sailed for a short time along the coast of Brittany, and the French hastened out of the harbour to meet them, when each party appeared eager to engage. They began the engagement with great fury; but the most remarkable event that occurred, was the destruction of the two largest ships, in the act of close conflict; these were, the French ship *Cordelier*, and the English ship *Sovereign*, which was considered to be the largest ship in Europe; they were grappled together in action, when the former of them became enveloped in flames, which were communicated to the latter. The result was, that they both blew up; but the origin of the calamity was never accounted for; the catastrophe struck the beholders with terror, and the action was suddenly terminated, whilst the conclusion deprived both parties of any just claim to a victory. The English, however, rallied; and the next day they began to scour the channel, in which they took a great number of French vessels, "small and great," and burnt such as they were unable to send home.

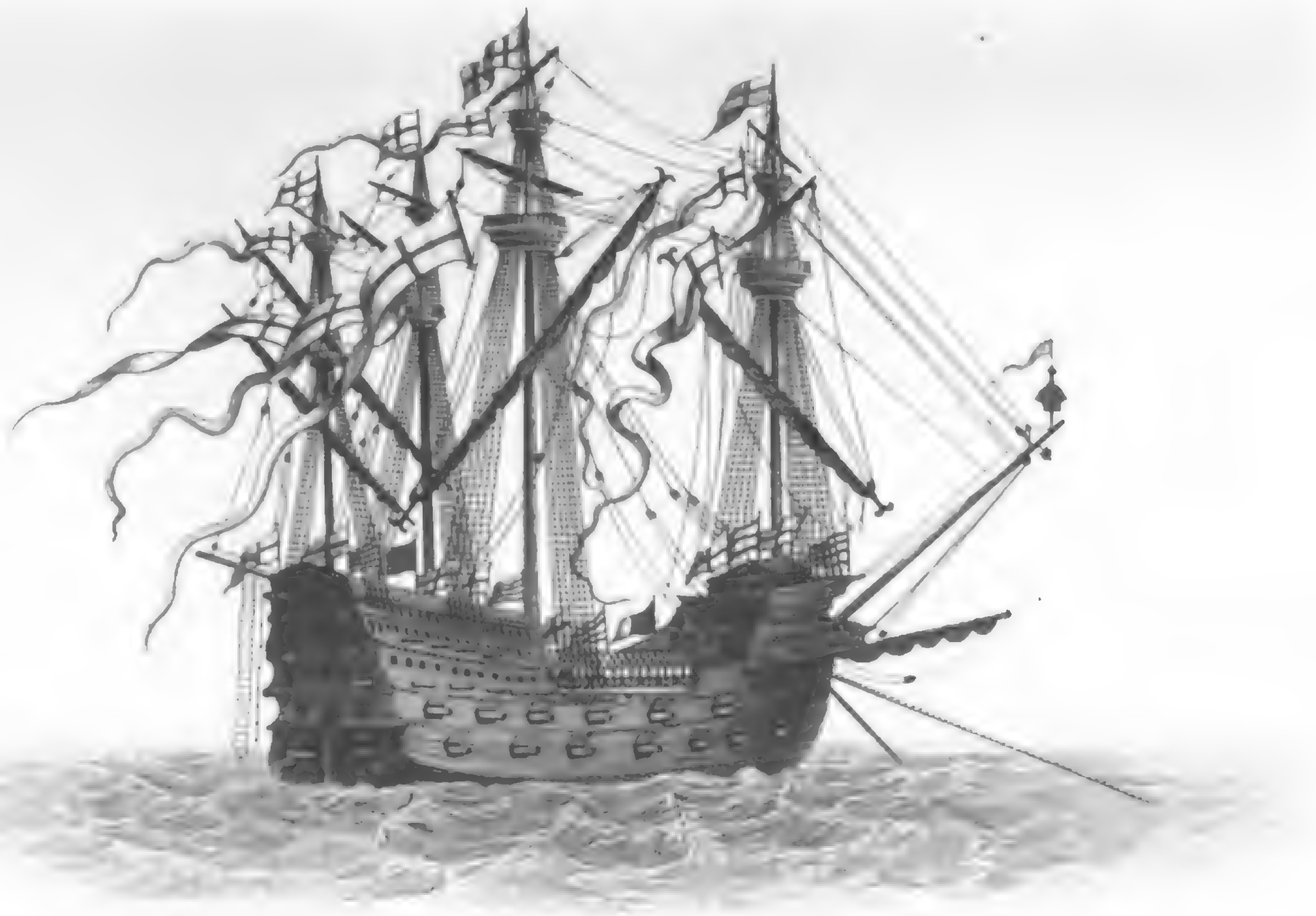
In consequence of the loss of the *Sovereign*, Henry ordered a still larger ship to be built, called the *Henry Grace de Dieu* (*Plate* 12); she is said to have cost nearly eleven thousand pounds; and in a list of the navy, given by Mr. Pepys, her burthen is stated to have been 1,500 tons, although most other accounts say she was only 1000 tons.

Early in the year 1513 a fleet was fitted out, and sent to sea under the command of Sir Edward Howard, who, on arriving upon the coast of Brittany, found the French fleet lying in the harbour of Brest. Perceiving that it was impossible to conduct his ships into the harbour to attack the French, he set out from his fleet with a small number of row-barges and boats to attack them; thus setting an example of that dangerous kind of service in which so much heroism has been displayed in later ages. The intrepid admiral in the foremost boat appeared at first to gain some advantages; but those who followed, failing to support him, gave the French an opportunity to rally, which they did, and completely overcame the admiral and his boat's crew, and with their pikes forced him and almost the whole of them overboard; this event so dejected the English, that, without making any further attempt upon the enemy, they returned at once to England.

At this time the Scotch were in alliance with the French; and in the prosecution of the war that was now going on between England and Scotland, James the Fourth of the latter was killed in the battle of Flodden Field; and after this event, both Henry and Louis were willing to negotiate for peace; and both Francis the First (who soon succeeded to the throne of France), and Maximilian the First, Emperor of Germany, showed a disposition to court the friendship of King Henry. This harmony prevailed, however, only a few years; the Emperor of Germany and the King of France were both desirous to have the alliance of England; the former succeeded, and England and France were soon involved in a war, which began in 1522, and lasted till 1527. Sir Thomas Howard, who had been created Earl of Surrey, and appointed, after the death of his brother, admiral of England, was also appointed by the emperor, admiral of his navy, "which consisted of one hundred and eighty tall ships."

During the first year of the war, the employment of the navy was of a desultory character, doing considerable damage to the French, without tending materially to advance the objects which war generally contemplates. In 1523 an attempt was made by the French to burn the English fleet lying at Calais; but the vessel which they had provided for that purpose missed the entrance of the harbour in the night; and being then set on fire, and driven ashore at a short distance from the town, betrayed the attempt, and exposed its failure. During this year an insufficient

Plate 12 [illegible]



protection was maintained in the channel, a circumstance of which the French took advantage, by sending out small squadrons to attack English vessels near their own shores; one of these squadrons, consisting of six vessels, attacked an English galley of about forty tons. Although the latter was imperfectly manned, a most resolute fight was maintained for about five hours; the arrows of the English being at length all expended, they endeavoured to secure their ultimate safety by flight. In this condition the galley was seen from Sandwich haven, and a bark was immediately sent out to her relief; the French then relinquished the pursuit of the galley to attack the bark; the crew of the latter defended her for several hours, until their arrows were all spent, and the masts beaten down; when having no longer the means of defence or escape, she was carried by the enemy, who conducted her into Dieppe.

After the French war was concluded in 1527, the occasions for naval service presented by the war with Scotland were not sufficient to engage the requisite amount of attention to that establishment. During this interval, both the navy and the important naval stations on the southern coast sank into an almost defenceless condition; and hence in the year 1540, when there was some prospect of a war, Henry caused all the most convenient landing-places to be surveyed and fortified, and ships to be prepared for sea, "to his great cost and charges;" but the crisis did not arrive till 1543, and then the operations of the war were carried on principally by land.

At that time the war with Scotland was being carried on; and Henry sent thither a fleet of nearly two hundred vessels, which conveyed an army of ten thousand men; but little more, on an average, than fifty men to each. During this war a general license was given for fitting out privateers, to be employed against the subjects of both France and Scotland, without being liable to render any account for the prizes they took. They soon brought in a large number of French vessels; and as the opportunities were diminished of seizing vessels belonging to the national enemies, those belonging to neutral states were likewise captured, which gave great discontent; and English merchants' ships were detained in foreign ports with a view to obtain restitution. Little, however, appears to have been done by the navy until 1545: the French then fitted out a fleet of more than two hundred sail, besides galleys, with a design of invading England. Whilst these were lying in port, waiting to have the preparations for the expedition completed, Lord Dudley, the English Admiral, made an attempt to bring the French to a general engagament, as he was unable to enter the harbour with his fleet to attack the French there. His fleet consisted of one hundred and sixty sail; and having approached sufficiently near to fire upon the French ships, their galleys hastened out to engage the English; but as the wind soon increased, both parties were obliged to discontinue the action, the galleys to return to the security of the port, and Lord Dudley's fleet to obtain sea-room. The English then directed their attention to the security of their own shores; defensive preparations were made with great dispatch, at Portsmouth and in the Isle of Wight; and the fleet was assembled at Portsmouth.

The French were still intent upon accomplishing the invasion they had projected; but they were subject to several disasters that materially diminished the force they had calculated on being able to bring to the execution of their design; many of the ships which had been hired, arrived too late from the Mediterranean; others were lost by unskilful management; and the best ship in the navy of France, and which was considered to be the finest and best sailing ship upon the sea, caught fire and was entirely destroyed. This ship, it is said, was 1200 tons burthen, and carried a hundred large brass guns. Notwithstanding these disasters, the French fleet consisted of one hundred and fifty large ships, sixty "small vessels," and twenty-five galleys. Proceeding now across the channel, the French landed some troops, on the 18th of July, upon the coast of Sussex; but these were compelled soon to retire. The next point of attack was the Isle of Wight; but the English were lying at St. Helen's ready to receive them: the French approached; but on the first day little was done; for although the enemy's galleys came near enough to exchange shot with the English ships, there was not enough wind for the latter to pursue their antagonists. The French now suffered another loss; their best ship, in which the admiral intended to fight, sprang a leak, and was, in consequence, sent back to be repaired. The next day, as the English were proceeding out to attack the French, the *Mary Rose*, one of the largest ships (500 tons burthen*), sank, and almost all on board were drowned.† The French affirm that this accident was occasioned by the firing of their cannon; but the English say it was caused through "great negligence;"—that she was overloaded with ordnance, and

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* Macpherson, Vol. II., p. 41.

† In an account of the loss of this ship, written by Sir Peter Carewe, who was an eyewitness of the event, it is stated that on the day when it occurred, the king was on board the *Great Henry*, the ship of the Lord Admiral, Viscount Lisle, with whom he dined. During the time of the repast he made inquiry if anything was to be seen at sea; and Peter Carewe immediately went "to the top of the ship," and reported that three or four ships were in sight, which he thought were "merchants." And after he had remained there a short time, he saw, "as he thought, a fleet of men-of-war." It was rightly supposed that this was a French fleet; and orders were immediately given for all the officers and men on board the *Great Henry*, to return to their respective ships. And the king himself returned to the shore, after having conferred privately with the Admiral and Vice-admiral of the fleet.

Shortly after the fleet had been got under weigh, Sir George Carewe observing that his ship, the *Mary Rose*, heeled considerably, called the master, and inquired of him "what it meant." And he replied, "that if she did heel she was like to be cast away." About that time, Sir Gawen Carewe, in his own ship, passed the *Mary Rose;* and hailing Sir George, asked him how he did; to whom Sir George replied, "that he had a the lower ports, which were within sixteen inches of the water, were left open; so that when she should turn, the water entered, and she sank suddenly. The French sent their galleys in to fire upon the English, apparently to bring on a general engagement; but as the wind rose, enabling the English to make use of their sails to advantage, the enemy's ships and galleys retreated: no general action ensued, and the English returned into Portsmouth. It appears that this fleet was decidedly inferior to that of the enemy; for the French landed in the Isle of Wight, and contemplated an attack upon the English fleet as it lay in the harbour; but on surveying it in the night, the entrance was found too difficult of navigation for the enterprise, which was not therefore attempted, and they retired from the coast. No attempt appears to have been made to destroy their fleet.

The next object of the French appears to have been the recovery of Boulogne; and Lord Dudley received orders to proceed to sea, with a view to defeat their aim with respect to that place. Instructions were given by the admiral for conducting the action in case the fleets should meet, which happened on the 15th of August: but each admiral was so concerned to secure an advantage over the other, that the evening came on before the action began. The French galleys, and some of the smaller English ships came, however, to a partial engagement; but before the French ships could join in it, "their galleys were well beaten and repulsed towards them." Dudley adds, that this "being no time for two such armies to begin a fight so near night, gave me occasion to think that they rather minded to make us afraid than to do us any harm; and when they were come within a league of us, I caused our fleet to come to an anchor, to the intent that they should perceive we were not afraid of them." After this the enemy retired; and the next morning they were scarcely visible to the English, while no advantage appears to have been gained on either side beyond that of preventing the French from landing on the shores of England. But little occurred in the employment of the navy during the war beside the defence of Boulogne, which the French made considerable efforts to recover. After the peace, made in June, 1546, nothing of importance transpired during this reign, with respect to the navy. Henry died on the 28th of January, 1547.

The naval establishments of England were much advanced during the reign of Henry the Eighth. As an *establishment*, the navy had just begun to exist previously to his ascending the throne, and it was he who "laid the

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set of knaves whom he could not rule." Soon after this, the *Mary Rose* was observed to heel more and more; and very shortly afterwards she sank, having 700 men on board,—very few of whom were saved. One hundred of the mariners of this ship were said to have been such good seamen, that the worst of them was "able to be master of the best ship within the realm." But being insubordinate, each refused to do what was requisite; and, by neglect, brought upon themselves a common destruction.

foundation and settled the constitution of the present royal navy."* The admiralty and navy board were formed, and the Trinity-house founded; offices were appointed for the regular transaction of business relating to the navy; and the officers were directed to assemble in committee once a week, on Tower-hill, to deliberate on the best means of promoting the efficiency of the naval establishment, and to make a monthly report of their proceedings to the Lord High Admiral. The dockyards of Woolwich and Deptford were established, and that at Portsmouth greatly improved. But notwithstanding the advance which was made in the navy as a national establishment, the services to which the Cinque Ports were liable, were still enforced when they were required. The royal naval power in the time of war did not, according to Derrick, exceed 12,455 tons, and 7,730 soldiers and mariners: at the death of the king it "consisted of 71 vessels, thirty of which were ships of burthen, and contained in all 10,550 tons; and two were galleys, and the rest were small barks and row-barges from 80 tons downwards to 15 tons, which served in rivers, and for landing of men."† ‡

In the reign of Edward the Sixth, little service was required of the navy; a war with Scotland occasioned the most important expedition that was undertaken. The fleet employed on this occasion amounted to sixty-five sail, of which thirty-five were "ships of force;" the rest were employed in the conveyance of provisions and ammunition, partly for the service of the army, which marched northwards by land, and arrived in Scotland about the same time as the fleet. Much injury was done to that country by this fleet, which ravaged the coast, entering the ports, and destroying the ships and vessels that were in them; so that it was said they did not leave a single ship of force in the kingdom. As soon as a respite was obtained, the Scotch took effectual means to frustrate the designs of the English in this war; and when this was seen to be the case, the path was open for the restoration of peace, which was concluded in 1549. The navy declined materially during this reign, although there appears to have been a regular, but limited employment of it in the winter and summer guards,—the former consisting of 2150 tons of shipping, with 1516 men, and the latter of 2540 tons, with 1730 men. There were twenty-four ships and pinnaces in good condition for service, one of which is supposed to have been the *Henry Grace de Dieu*, then called the *Edward*; and twenty-two others, in various conditions, make up the total of the navy in 1552.§

Edward the Sixth died in July, 1553, and was succeeded by his sister Mary, during whose reign, little relating to the navy claims to be noticed, except that that establishment continued to diminish; when the country was on the eve of a war with France in the year 1557, it consisted, according to Mr. Pepys's statement, of no more than twenty-one ships and vessels

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* Campbell, Vol. I., p. 323.

† Derrick's Memoirs of the Royal Navy, p. 10.

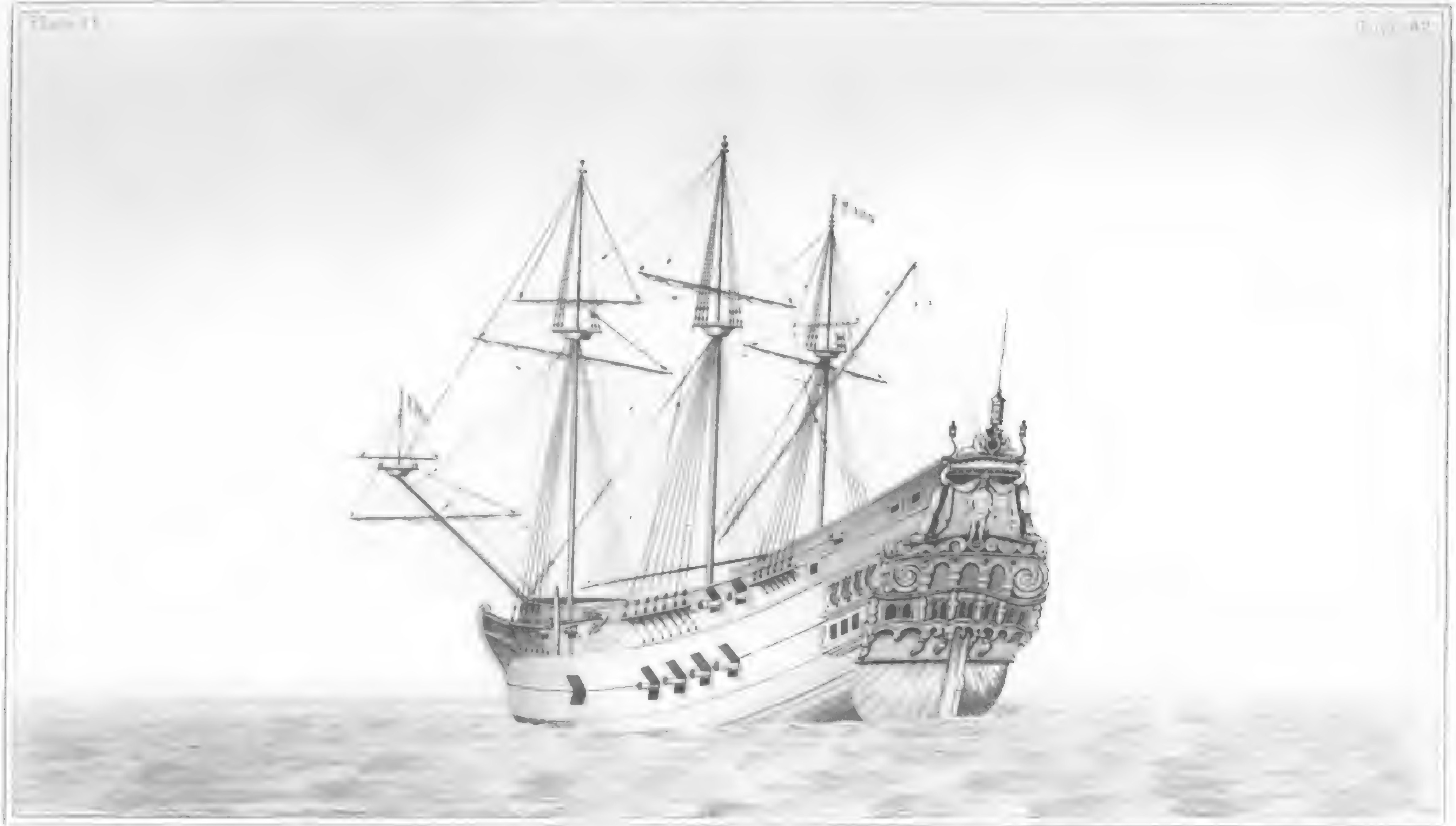
‡ Plate 13 is that of a Genoese carrack of 1542.

§ Pepys' Miscellanies.

A GENOESE CARRACK A.D. 1542.

Plate 11.

Page 82.



of 4380 tons burthen, carrying 302 arquebusiers, 568 soldiers, 324 gunners, and 1988 mariners. The war which followed was not productive of any valuable results to the navy; the fleet was united with a Spanish fleet in some of the operations; nothing was gained; and the result of it was, that Calais, the last remnant of English conquests in France, was lost. In the negociations for peace which followed, the restoration of this place was at first urged; but the queen died in November, 1558, before the peace was concluded.

The reign of Queen Elizabeth may be regarded as a new era in the maritime history of this country, not only by the immediate consequences that resulted to England in the rise of its naval power to its then surpassing eminence; but, by that private enterprise in navigation and commerce, which so materially advanced the prosperity of the country beyond what it had previously reached. These enterprising adventures were generally encouraged by the queen and her council, in a manner which increased both their energy and their importance.

With respect more particularly to the British navy, it may be observed, that as only a remnant of it remained, when Elizabeth came to the throne, so whatever efforts were made towards its improvement during the early part of her reign, appear to have aimed more at the quality of the ships which composed it, than at the increase of their number. The service of the navy was soon required, as the negociation for peace had not been concluded during the life of Queen Mary; and, subsequently to the conclusion of peace in the following year, owing partly to the unsettled relations between England and Scotland, it was frequently necessary to employ a squadron for the purpose of suppressing irregular proceedings in the channel. A general permission having been given for privateering, that practice degenerated into indiscriminate piracy, by which neutral, as well as belligerent states suffered; the practice was checked by a vigorous employment of a small squadron in scouring the channel.

As soon, however, as the country was free from the charge and the anxiety of war, the queen directed her attention more particularly to the condition of the navy; she ordered a special survey of it to be made, and the causes of its recent decay investigated; ships of various sizes were built, adapted both for war and commerce; and large quantities of arms were imported from Germany, with which the arsenals were well supplied: gunpowder was made, and brass ordnance cast for the service of the navy in England, whereas these things had been formerly imported from abroad. But that which appears to have tended most extensively to improve the maritime power of England, was the encouragement the queen gave to her wealthy subjects to build ships of burthen, and promote and extend navigation generally; and by this means, principally, the maritime condition of England soon became so altered, that Elizabeth was called by foreigners *the restorer of the glory of shipping, and queen of the North sea.*[*] During a number of years subsequently to Elizabeth's accession, the number of ships in the navy appears to have been decreasing; for, in 1565, the navy consisted of twenty-nine ships and vessels, but in 1578, it consisted of only twenty-four ships of all sizes; the largest was the *Triumph* of 1000 or 1100 tons; and the smallest the *George* of not quite 60 tons.[†] "At the same time, all the ships throughout England of 100 tons and upwards, were but one-hundred and thirty-five; and all under 100 and upwards of 40 tons, were six-hundred and fifty-six."[‡] Seven, out of the twenty-four ships of 1578, became unfit for service within the ten succeeding years; but, during that interval, a greater number of new ships were built; for, in the fleet sent out against the Spanish Armada, there were eighteen new ships employed, the largest of which was the *Royal Ark* of 800 tons; the *Elizabeth Bonadventure* was of 600 tons; three ships were of 500 tons each; and the remainder were of less burthen.[§]

It must not be understood that the defence of England rested upon the very limited navy which belonged to the government; recourse was had to merchant ships, which were hired for the temporary service, as a considerable number of these when fitted for war, were classed as line-of-battle ships, carrying at least between 40 and 58 guns.[||]

The extended voyages which had become common since the beginning of the century, and which were growing increasingly important under the reign of Elizabeth, proved and frequently illustrated the importance of cultivating marine architecture, and of rendering the improvements in this art commensurate with the growing demands of commerce and enterprise. Already a sheathing had been applied as a protection to the bottom of ships employed in navigating the West Indian seas; and as early as the year 1553 the English applied a metallic sheathing, a practice of which the Spaniards had previously given an example.

In the year 1577 Captain Francis Drake undertook that voyage, which has ever since been memorable in English maritime history; but the squadron which he fitted out for an expedition into the Pacific ocean, showed most clearly the urgent necessity of increasing the dimensions of vessels suitably to the greater hazards incident to long and dangerous voyages. Five vessels constituted this squadron; the *Pelican*, of 100 tons burthen; the *Elizabeth*, of 80; the *Swan*, a fly-boat, of 50; the *Marygold*, of 30; and the *Christopher*, a pinnace of 15 tons. And they were manned with 164 men, gentlemen, and sailors. During the voyage a variety of disasters occurred, only three of the vessels passed through Magellan's Straits; these were afterwards separated; one was never again heard of; a second returned to England, the captain of her despairing of meeting again with Drake; whilst Drake alone in the *Pelican*, accomplished all that had been designed in the expedition; plundering the Spaniards, both by sea and land, of immense treasure, with which he returned by the Cape of Good Hope, and arrived at Plymouth, after an absence of two years and nearly ten months.

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[*] Camden, Strype's Annals.

[†] Charnock, vol. 2, pp. 55, 58; Derrick.

[‡] Campbell, vol. 1, p. 425.

[§] Charnock, vol. 2, pp. 59, 60.

[||] Burchett.

The assistance which the queen supplied to Holland when that, with the other provinces of the Netherlands, was endeavouring to throw off the yoke of Spain, led the queen to expect a rupture with that country. This apprehension was confirmed by several occurrences; and preparations were made to defend the nation when the crisis should arrive, if the stroke could not be averted. The naval preparations of Spain were far greater than the English could make; and it appears to have been the design of the English government to destroy those preparations before they should have been completed, as in April, 1587, Drake was sent out with "four large ships and twenty-six smaller vessels," which were supplied by the citizens of London. Whether or not it is possible to arrive at a certainty with regard to the instructions this commander received for the conduct of his expedition, this appears clear, that his attention was directed against whatever naval preparations he found in the ports of Spain. Proceeding to Cadiz, he found lying in the bay a richly-laden fleet, which he immediately attacked, and destroyed "one hundred vessels laden with ammunition and naval stores, and sank two galleons," both richly laden. When he arrived off the Tagus, he found a squadron lying there, and attempted to induce the admiral, commanding it, to give him battle; but his challenge was given in vain. So extensive, however, was the injury done to the navy of Spain, that the projected invasion of England, for which the great preparations were making, was laid aside until the next year; and the interval was employed by Spain, principally in repairing the damage that Drake had done; and by the English, in raising to the best possible condition the defensive power of the kingdom.

At length, the loss of the Spanish navy having been repaired, and its preparations completed, King Philip caused an account of them to be published; and according to this account, it "consisted of 133 ships, making in all 57,868 tons, on board of which were 19,295 soldiers, 8,450 mariners, 2,088 slaves, with 2,630 pieces of cannon."*

The list published by Charnock, of the ships constituting the Armada, differs from this statement in some degree; and perhaps the details of it, which cannot be given here, entitle it to confidence.

The navy of England, consisting of all the ships, both public and private, that could be fitted out on the great emergency that now presented itself, amounted to a hundred and ninety-seven sail; only thirty-four of these could, however, be regarded as the *Royal Navy;* and all these, except two, were below 1000 tons burthen. The burthen of the *Triumph* was 1,100 tons, and that of the *White Bear* 1000 tons; the *Royal Ark* and the *Victory* were 800 tons each; the *Elizabeth Bonadventure,* the *Mary Rose,* and the *Hope,* were 600 tons each. There were six ships of 500 tons each, three of 400, one of 360, one of 300, two of 250, two of 200, one of 150, two of 120, and one of 100 tons; the remaining eight varied from 90 to 30 tons. The burthen of these thirty-four ships and vessels amounted to 11,850 tons. There were eighty-three ships varying from 400 to 100 tons burthen, amounting altogether to 14,565 tons; fifty-eight vessels varying from 90 to 30 tons each, of which the entire burthen was 3,329 tons; besides these, there were fifteen victuallers, and seven other vessels of which the tonnage is not given. These all accompanied the *Royal Navy* when it sailed forth from the ports of England to defeat the Spanish Armada.

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* Campbell, Vol. I., p. 431.

In the month of May, the Armada being ready, and all the preparations for the enterprise made, it put to sea on the 28th of that month; and on the following day a gale of wind did so much damage to the ships, that they were obliged to return into port to be refitted. This occasioned a delay of several weeks; and intelligence of the disaster having reached England, it was supposed the danger of invasion was over for the season, and Walsingham was ordered to write to the Admiral Lord Effingham, directing him to lay up some of the ships, and to discharge the seamen; but his advice, to keep all the ships in a condition ready for service,* appears to have prevailed.

In July the Armada was again ready for sea; and on the 19th of that month, intelligence of its approach was conveyed to Lord Effingham as he lay at Plymouth with the fleet. He hastened out, and the next morning the Armada came in sight, arranged in the form of a crescent, extending several miles in length. In the inferiority of the English ships in comparison of those of Spain, it was deemed advisable to follow at a convenient distance, to seize any opportunity that might occur to distress the enemy, without a hazardous exposure of the English ships; and two large ships, being accidentally injured, and unable to keep up with the body of the fleet, soon fell into the hands of the squadron commanded by Sir Francis Drake. Several skirmishes took place as the fleets were sailing up the channel, resulting favourably to the English; as the Spaniards lost fifteen capital ships in the engagement, whilst the English lost only one.

An army had been assembled ready to embark, under the command of the Duke of Parma; the fleet was brought to an anchor off Calais, waiting for an opportunity to effect this embarkation. As the fleet lay at anchor, a number of fire-ships was sent against it, when the Spanish ships were obliged

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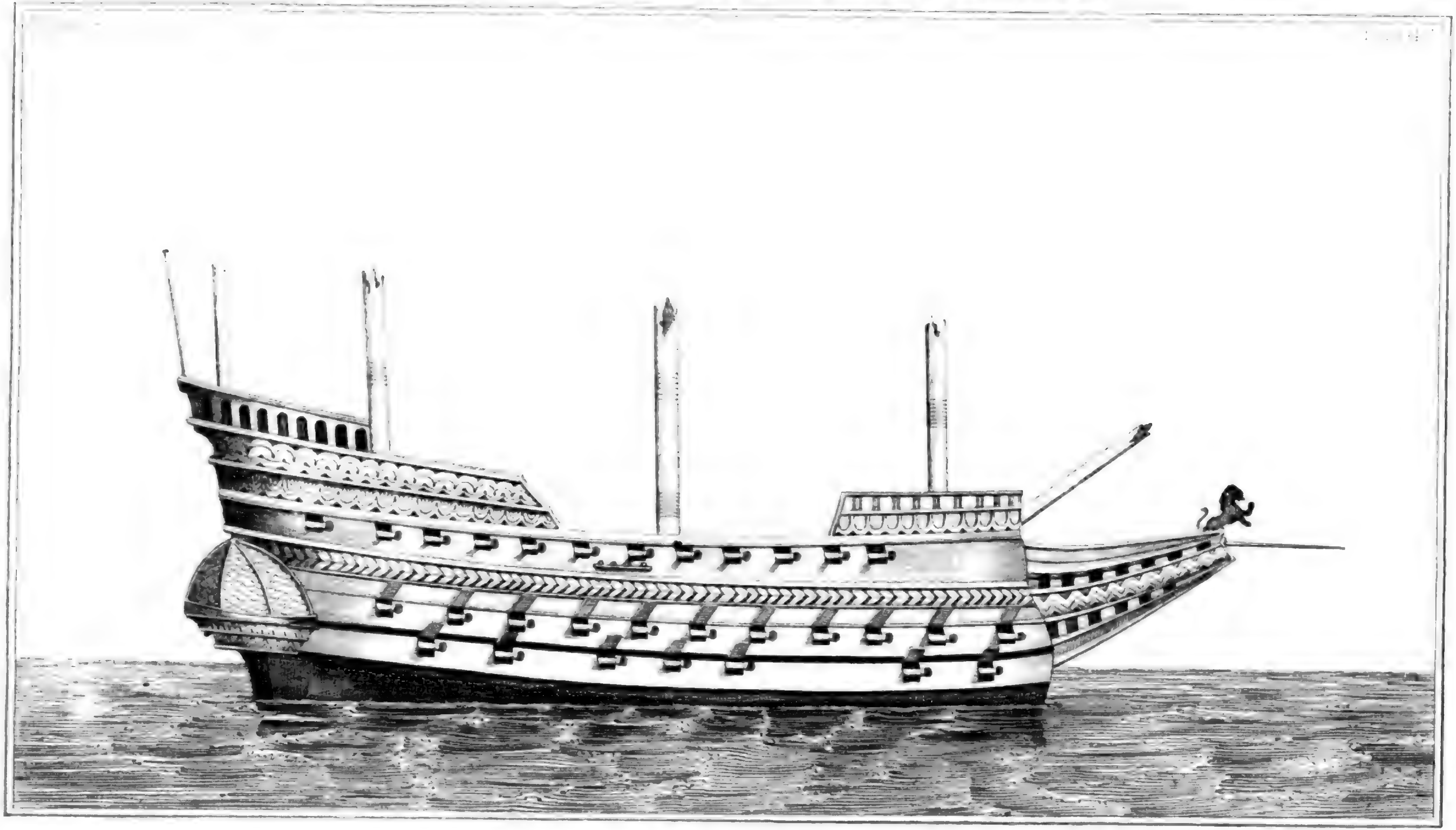
* Camden.

A BRITISH SHIP OF WAR IN THE REIGN OF QUEEN ELIZABETH.



to fly in confusion. The presence of a Dutch squadron rendered the embarkation of the army impracticable; and the Spanish officers, in a council of war, soon came to the conclusion, that no hope remained of carrying into effect the projected invasion. Tempestuous weather scattered their ships, many of which were wrecked, and only fifty-three returned to Spain.

There was a striking difference, generally, between the English and the Spanish ships; many of the latter were large and unwieldy, and were good objects for attack by cannonade; whilst either from the character of the ships, or the unskilfulness of the seamen in managing them, they could be approached and fired into, without much danger, by their more active antagonists, who then retired to a safe distance; whilst, with but few exceptions, the English vessels were so low in the water that the shots from the galleons passed over them; a fact which showed sufficiently that too little attention had been paid to the dimensions of the ports and the means of working the guns. Their largest ship was of 1,550 tons burthen; but although no uniformity was maintained between the burthen of the Spanish ships and their armament, their tonnage was generally large in relation to their force,—a superiority which long distinguished them. Further, as the science of naval architecture was formerly encouraged more in Spain than elsewhere, the ships of that country were before those of the more northern nations of Europe, in possessing the excellence of form from which both fast sailing and other good qualities result. This superiority was exhibited in some of the Spanish ships which were captured at the battle of Trafalgar. *Plate* 14 represents one of the largest of the few large ships in the British navy about the same time.

Probably no event in the history of this country ever called forth a more energetic display of national feeling and patriotic courage, than was called forth at the approach of the Spanish Armada.

It appears to have been now an established maxim, that the navy was the greatest bulwark of the kingdom; and the importance of it, as a national defence, in the recent alarming circumstances, having been so signally displayed, the annual sum of eight thousand nine hundred and seventy pounds was set apart for the repairs of it.

Several expeditions were afterwards undertaken, during this reign, against the Spaniards; but most of the ships employed in them belonged to private adventurers. And hence, in a time when so much was seen to depend on the dominion of the sea, the royal navy increased with a comparatively slow growth, when viewed in connection with the events of the time; for the nation was kept in constant apprehension for several years, that repeated attempts would be made by the Spaniards to accomplish the invasion, and it was conceived that the most politic course was to send such a fleet out occasionally, as would be able effectually to derange the proceedings of Spain, and prevent her sending out a powerful armament.

Some material improvements took place in naval architecture; and sir Walter Raleigh, in speaking of these, says, "in my own time the shape of our English ships has been greatly bettered." He continues, "The striking of the topmast hath been devised, together with the chain pump; we have lately added the bonnet and drabler to the courses; we have devised studding-sails, and sprit-sails. The weighing of the anchor by the capstan is also new. We have fallen into consideration of the length of cables, and by it we resist the malice of the greatest winds that can blow; we have also raised our second decks." Improvements in the general state of the navy went on from the time that England, by joining with Holland, subjected herself to the prospect of a war with Spain; and during the last twenty years of the queen's life, the royal navy was almost doubled. At her death, which occurred in March, 1603, it consisted of forty-two ships and vessels, whose aggregate burthen amounted to about 17,110 tons: the *Triumph*, of 1000 tons, which was one of the largest, was a 68-gun ship; and the annual expenditure, during the latter part of this reign, is said to have been thirty thousand pounds.

The accession of James the First was followed by a restoration of peace, as soon as the requisite negociations between England and Spain could be completed. The peace was, however, concluded without reference to the Dutch, by whose alliance the British fleet had, in the time of the greatest danger, received essential aid; and the amicable relations which were now established between these two great naval powers, whilst the war was continued on the part of Holland, led to a constant display of jealousy and ill-feeling of the Dutch towards the English for a number of years; and this was almost the only occasion that existed for the maintenance of a fleet in commission in the channel, during the early part of the reign of king James.

Sir William Monson commanded this fleet; and enforced the observance of the customary mark of respect to the British flag, with so much rigour, that the Dutch always conceded the point to their rival in maritime power. For the English and Dutch were now rivals on the sea; the latter having, since the recent period at which their navy had had its origin, cultivated that power with indefatigable diligence and perseverance, as a national object, until it had acquired a very formidable character.

It was with difficulty that the English could provide the means for maintaining the fleet in the channel during this period; and we find particular inquiry was made with regard to a reduction in the expense of the naval establishment, under the earl of Nottingham, as lord high admiral, an officer of experience and ability; and the result of the inquiry brought the estimate of a year's expenses down to the sum of £20,876 13*s*. 4*d*. One of the items in this estimate included the charge "for graving ten of his majesty's ships yearly, that all the fleet might be graved once in three years;" hence it appears that thirty ships were considered sufficient for the service of the country.* The inquiry regarded the abuses of the naval establishment, and was directed to the correction of them; and much was done towards improving the general administration of its affairs by this strict investigation. Naval architecture also received considerable improvement from the skill and labours of Mr. Phineas Pett, who constructed the *Prince Royal* in 1610. The following account of this ship is copied by Charnock:† "This year the king builded a most goodly ship for warre, the keel whereof was 114 feet in length, and the cross-beam was 44 feet in length; she will carry sixty-four pieces of ordnance,‡ and is of the burthen of 1400 tons. This royal ship is double built, and is most sumptuously adorned within and without, with all manner of curious carving, painting, and rich gilding, being in all respects the greatest and goodliest ship that ever was builded in England; and this glorious ship the king gave to his son, Henry prince of Wales; and the 24th of September, the king, the queen, the duke of York, and the lady Elizabeth, with many great lords, went unto Woolwich to see it launched; but because of the narrowness of the dock, it could not then be launched; whereupon the prince came the next morning by three o'clock, and then at the launching thereof the prince named it after his own dignity, and called it the *Prince*. The great workmaster in building this ship was master Phineas Pett, gentleman, some time master of arts at Emmanuel college, Cambridge."§

A circumstance is noticed in 1613, that Mr. Pett began to victual all the shipwrights and workmen then employed.

In April 1606, Mr. Phineas Pett was elected and sworn the first Master of the Shipwrights' Company. On this occasion, he says, they kept a feast with a great number of their friends at the "King's Head," New Fish-street. And, on the new charter, granted in 1612, to the master, wardens, and commonalty, of the art and mystery of ship-building, for incorporating the shipwrights of England, he was ordained the first master.

In 1619, a reference is made to the wardens and assistants of the Shipwrights' Company, respecting the survey of ships at Deptford; and in the Naval Minutes of Mr. Pepys, it is observed, that "the Shipwrights'-Hall did anciently view and approve of the draughts of ships that were to be built for the king, and survey them in the building."

The successful efforts of Pett established his fame, whilst they advanced the interest and power of the British navy; and the fame thus acquired descended to his posterity with the profound secrecy of his profession. The impulse which was now given to naval architecture was so well sustained, that when the commissioners, appointed in 1618, drew up a statement of the navy, it was shown that there had been sixteen new ships and vessels added to it during the fifteen years of the reign of king James; but several of them were very small.* The bold deviation from established usage with which Mr. Pett set out, raised the character of British ships of war, and contributed mainly to that extension of naval power, by which England afterwards became so eminently distinguished. The commissioners gave a list of forty-two ships and vessels; twenty-seven of which were deemed serviceable, although eighteen of them were a part of the remainder of Elizabeth's navy; and eight of these had been employed against the Armada in 1588. The burthen of this serviceable part of the navy was 11,970 tons, and that of the unserviceable part was 4070, making together 16,040 tons; but the tonnage of several of these ships varies from what was stated to be their burthen at the close of the last reign. Of the fifteen ships and vessels that were considered unfit for future service, the *Triumph* was the largest; and four galleys of 100 tons each, and several smaller vessels had been launched since the accession of James.† The commissioners in taking notice of the dimensions of ships, affirm that, according to the judgment of the most skilful men, the length should be three times the breadth, and that the breadth should have a like proportion to the depth; but that a ship should not draw more than sixteen feet water; as they state that deeper ships are not good sailers, and are unsafe both in our rivers, and on the shallows of our coasts.

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* Charnock, Vol. II.. p. 186. † Vol. II., pp. 197-8.

‡ The *Prince* ordinarily mounted fifty-five pieces of ordnance, having vacant ports to be supplied in the time of action.—Charnock, Vol. II., pp. 197 and 274.

§ Shortly before this period, Sir Walter Raleigh wrote the first work connected with naval improvements, which no doubt had much influence in creating the great interest that took place about this time in naval matters. He wrote two discourses, one on the invention of Shipping, and the other on the Royal Navy and Sea-service.

Only one naval expedition was undertaken in the latter part of king James's reign; and that signally failed of sustaining the reputation of the English at sea. The expedition against Algiers was executed in 1620; and the fleet which was fitted out for that service, consisted of six king's ships, from 400 to 600 tons; and twelve ships from 100 to 300 tons, hired of merchants. Such a force sent out to inflict an effectual chastisement on that city for the piracies committed by Algerine ships, returned, as Sir William Monson, when he was consulted on the subject, expressed his opinion that it would, without having performed any important service; and that able commander afterwards remarked, "This ill-carried action was a sufficient subject of scorn for all nations to laugh at, considering the reputation this nation had gained in their former expeditions by sea." Little more of any interest in the navy occurred during the reign of James, which ended on the 27th of March, 1625, in the sixtieth year of his age.

Charles the First succeeded his father on the throne; and was influenced in his councils almost entirely by the duke of Buckingham, as the late king had been; this influence of the duke was highly important, as he still held the office of lord high admiral, to which he had been appointed in 1618.

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* Charnock, Vol. II., p. 213.

† Vol. II., pp. 212-13.

A war with Spain had commenced in 1624; but little was, however, done towards carrying it on. The first naval expedition that was projected in this reign was that of one king's ship, and six ships, each between 300 and 400 tons burthen,* hired of merchants, to serve under the orders of the French king against the protestants at Rochelle, whom severe persecution had driven to form themselves into a distinct community, and to defend themselves within the strong fortifications of that place: the fitting out of this trifling squadron is interesting only as it respects the conduct of the officers and men belonging to the ships. By the instructions given to captain Pennington, it was understood that they were to serve under the orders of the king of France against the Genoese; but when they arrived at Dieppe, the service for which they had been really intended became known; and as both officers and men disliked that service, they returned to the Downs. When captain Pennington reported to the king his return, he was ordered to sail again to Dieppe, and to place his squadron in the hands of the French king; this order was obeyed with respect to all the ships except one, which her captain, Sir Ferdinando Gorges, refused to leave for such a service, and again brought her to England; at the same time both the officers and men of the whole squadron, with the exception of one gunner, returned likewise; the gunner was killed as he was charging a cannon before Rochelle.

The war with Spain was not supported by a national feeling; and when, in October, 1625, a fleet was fitted out to destroy the ships and naval stores in the harbours of Spain, the king found no other means to obtain the money that was required for this expedition, than the issuing of privy seals for compulsory loans of his subjects. A fleet of eighty sail was fitted out; a part only of this fleet consisted of English ships—a Dutch squadron composing the other part; in this fleet 5000 mariners were employed, and 10,000 troops were embarked. Having sailed from Plymouth under the command of viscount Wimbledon, a storm soon came on which dispersed the ships; but proceeding onwards to the place of rendezvous, they assembled about the 19th of the same month off Cape St. Vincent: an attempt was made upon Cadiz; but being ill managed, it failed of gaining any advantage, as the Spanish ships were allowed, through the tardiness of the English, to retire to a place of safety before an attempt was made to capture them; and the attack upon the place itself was rendered fruitless by the divisions amongst the officers, and the want of discipline amongst the men. The other service which was directed to be performed, was the capture of the homeward-bound galleons loaded with treasure; the fleet did not, however, proceed immediately to intercept them; and a disease which had been caught by some men being communicated to the crews of all the ships by the general distribution of the sick men, the fleet was now rendered incapable of performing any further material service; and it therefore returned to Plymouth, arriving there in the month of December. This expedition having signally failed, another was projected; and for fitting this out, both ships and money were levied in the ports of England; and a hundred thousand pounds and twenty ships were required of the city of London. A remonstrance was made against the amount, which the citizens alleged they were unable to supply; at the same time, the lieutenants of three other ports complained of the imposition as unwarrantable; but the contribution of the respective amounts was enforced. Compulsory loans were likewise exacted from private individuals, according to the rate at which these individuals had been assessed in the last subsidy; these were the preliminary measures which led to the general imposition of ship-money.

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* Campbell, Vol. 2, p. 116.

The fleet which was now fitted out, consisted of one hundred sail, and had embarked on board between six and seven thousand troops; and a war with France having been determined on, this force was designed to take possession of the isle of Rhé or Ré, and sailed from Portsmouth in 1627. So little caution was observed in the conduct of this service, that the result of the expedition was very unfortunate. Rochelle, which was besieged by the French, appears to have been the real object towards which the attention of this fleet was to be ultimately directed; for the inhabitants of that place had looked to England for relief and succour, and fleets were fitted out avowedly to afford them that relief; but it is, perhaps, worthy of remark, that during this unhappy period, when the affairs of the navy were managed by the duke of Buckingham, and when the enterprises of it were therefore unpopular, none of them succeeded in the services for which they were undertaken. The war with both France and Spain terminated in 1629, and the relations of peace with those nations became permanent; but the tranquillity of England was permanently interrupted, chiefly through the continued imposition of ship-money. It is true that ship-building was carried on by means of the produce of that impost; and perhaps by far the most valuable result that the British navy derived from that taxation, was the building of the *Royal Sovereign*. In 1635 Mr. Phineas Pett received orders from the king to proceed to the north of England for the purpose of providing timber for the building of this ship: as Mr. Pett states, "On the 14th May, 1635, I was commanded by His Majesty to hasten into the north to provide and prepare the frame timber, plank, and tree-nails for the great and new ship at Woolwich. I left my son to see the moulds and other necessaries shipped in a Newcastleman, hired on purpose to transport our provisions and workmen to Newcastle. The frame, as it was got ready, was shipped and sent in colliers from

Newcastle and Sunderland." And having provided the materials, he says, "The 21st of December we laid the ship's keel in the dock; most part of her frame coming safe, was landed at Woolwich." She was launched at Woolwich in October, 1637; this ship was superior to any that had been built in England; but she was so gorgeously ornamented with carving and gilding, that she seemed to have been designed rather for a vain display of magnificence than for the service of the state.* So far was the building of this ship from reconciling the nation to the imposition of ship-money, that the excessive decoration which was bestowed upon her served rather to heighten and aggravate the resentment with which that impost had been all along regarded; for in the description of this ship, which was drawn up by Thomas Heywood, it is stated by the writer, after he had described the principal ornaments about her, that all those "works were gilded quite over, and no other colour but gold and black to be seen about her." "I now come," he says, "to describe her in her exact dimensions:—Her length by the keele is 128 foote or thereabout, within some few inches; her mayne breadth or wideness from side to side 48 foote; her utmost length from the fore-end to the stern, *à prora ad puppim*, 232 foote. Shee is in height, from the bottom of her keele to the top of her lanthorne, 76 foote; shee beareth five lanthornes, the biggest of which will hold ten persons to stand upright, and without shouldering or pressing one on the other.

"Shee hath three flush deckes and a forecastle, an halfe decke, a quarter-decke, and a round house. Her lower tyre hath thirty ports, which are to be furnished with demi-cannon and whole cannon, throughout being able to beare them; her middle tyre hath also thirty ports for demi-culverin and whole culverin; her third tyre hath twentie sixe ports for other ordnance; her forecastle hath twelve ports, and her halfe decke hath fourteen ports; she hath thirteene or fourteene ports more within board for murdering pieces, besides a great many loope-holes out of the cabins for musket shot. Shee carrieth moreover, ten pieces of chase ordnance in her right forward, and ten right aff, according to lande service in the front and the reare. Shee carrieth eleven anchores, one of them weighing foure thousand foure hundred pounds; and according to these are her cables, mastes, sayles, cordage."

The building of this ship clearly showed that a certain and most important advance had been recently made in the art; an advance that distinguished the age in which it was made. One of the most valuable qualities for which this ship was remarkable, was her durability; for after the Sovereign had been cut down, being then considered one of the finest ships in the world, she was constantly employed in those severe naval wars that called forth the utmost vigour of the nation during the government of

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* Phineas Pett's Journal.

Cromwell, and in the reign of Charles the Second. At length, this ship was laid up at Chatham in order to be rebuilt; but she was accidentally burnt, on the 27th of January, 1696. This ship appears to have been the first three-decked ship built in England. An original picture is said to have been painted by Vandevelde (*Plate* 15, and the form of the body, sheer, and half-breadth plans are given in *Plate* 16, with the comparative lines of a three-decked ship of the present day). Her dimensions were as follow:

Length on the gun deck............	173	feet	0	in.
„ of the keel for tonnage	139	„	$11\frac{3}{4}$	„
Breadth, extreme..................	50	„	0	„
Depth in hold	20	„	0	„
Burthen in tons........	$1861\frac{33}{94}$			

The *Royal Sovereign* was not, however, the first three-decked ship we have on record, since a Spanish ship with three decks, named the *Philip*, was engaged with the *Revenge*, Sir Richard Grenvil, off the Azores, in 1591. The *Philip* is described in an account written by Sir Walter Raleigh, who states, "The *Philip* carried three tier of ordnance on a side, and eleven pieces in everie tier. She shot eight forth right out of her chase, besides those of her stern-ports. Before this period, likewise, Chapman, the Swedish author, mentions a ship of great dimensions, called the *Makalos*, which was burnt in an action between the Swedes and Danes in 1564. He states her length to have been 168, and breadth 43 English feet; her armament, one hundred and seventy-eight guns, sixty-seven of which were cannon, and the rest swivels.

Charnock observes that "the wonderful stride towards the improvement of ship-building in general, and more particularly in vessels intended for warlike purposes, appeared to promise a rapid ascension to what should experimentally be considered as the *ne plus ultra* of perfection. Amidst every surrounding foible and improvident mark of conduct, the attention of Charles to this great naval concern was apparent in every action of his regal life, as long as he was permitted to exercise the functions of a king, uncontaminated and without restraint."*

In 1636 and 1639 fleets were fitted out; at the first period to restrain the Dutch from fishing; when they engaged to pay a considerable sum for permission to fish without molestation; and the service of the fleet was no further required. In the latter year, the fleet was fitted out in consequence of a combination of the French and Dutch fleet to prevent the Spaniards from having access by sea to the Netherlands. King Charles was requested to concur in this arrangement; but declining to do this, he engaged to be neutral. The fleet which was stationed in the Downs under the command of Sir John Pennington, was ordered to maintain the neutrality of the English ports; and as the Spaniards had taken refuge in the Downs whilst

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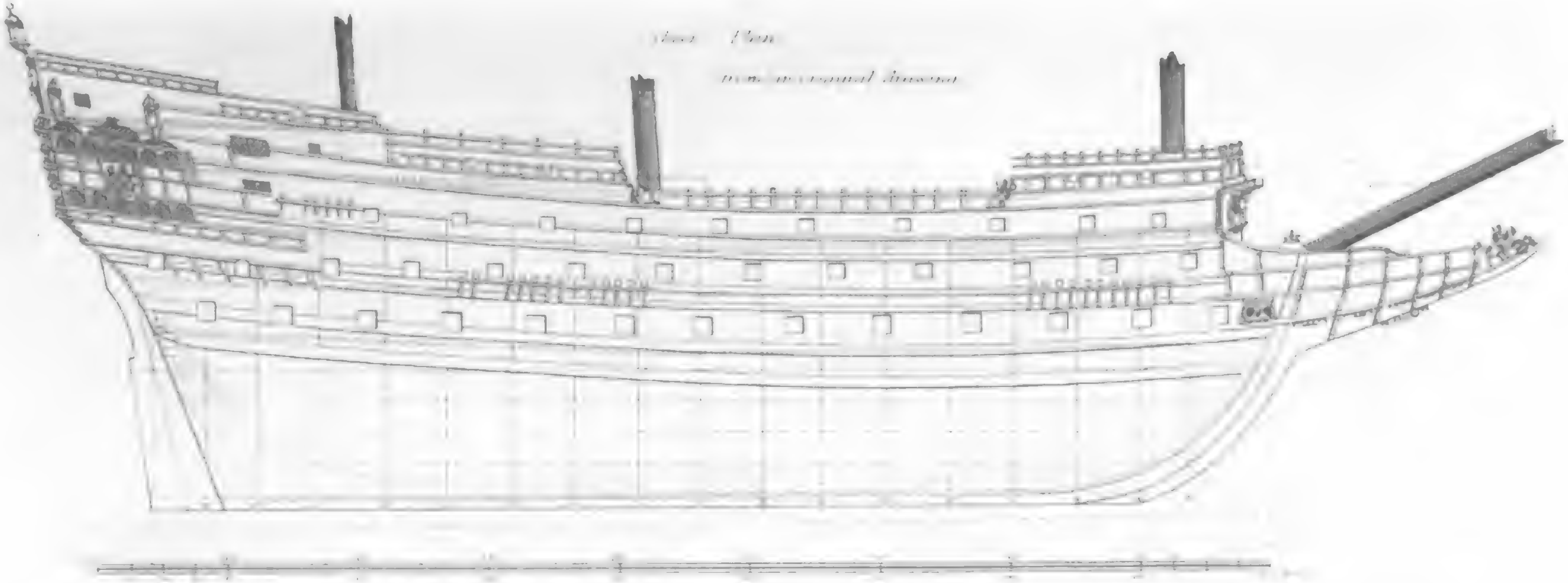
* Vol. 2, pp. 287-8.

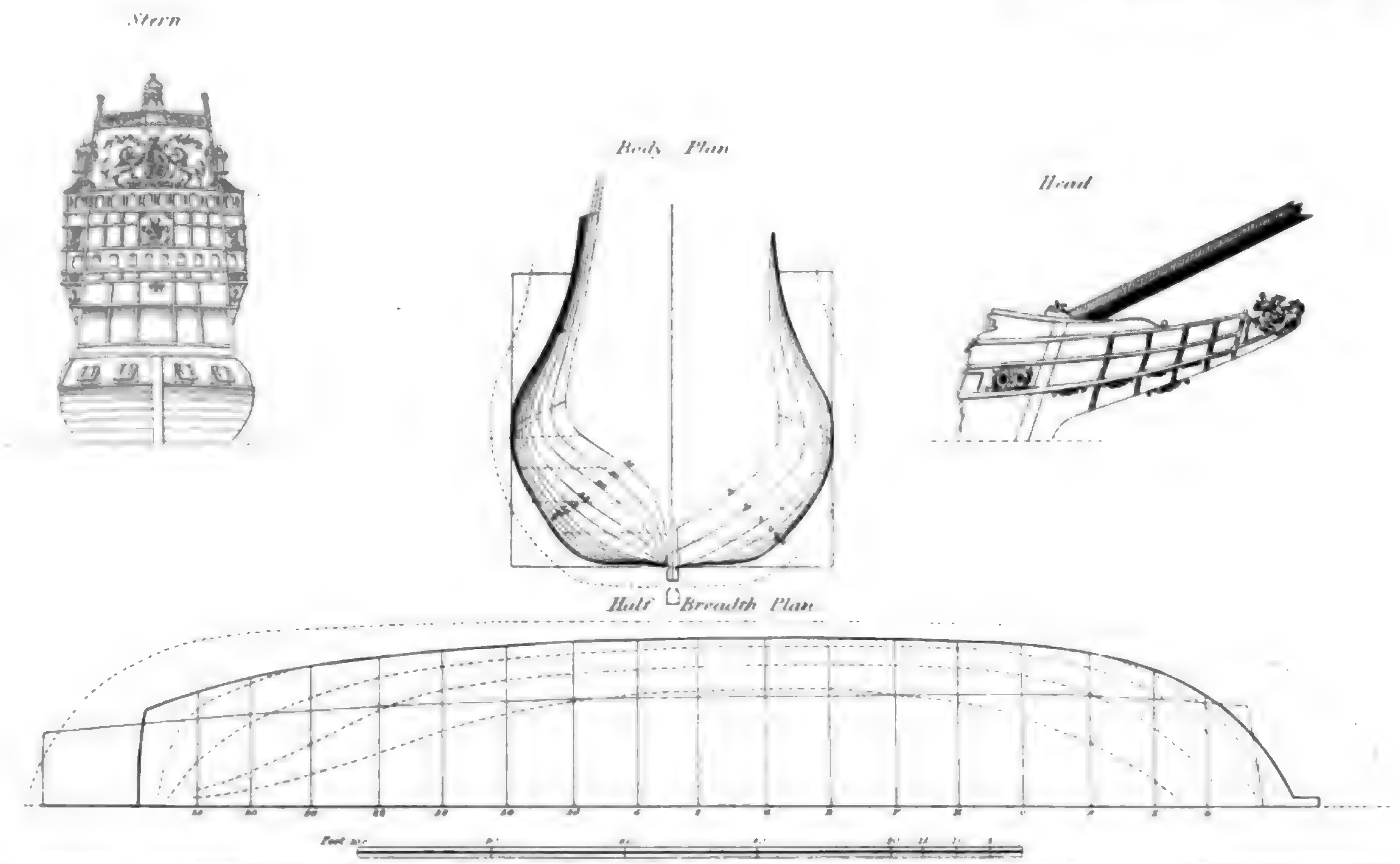
THE ROYAL SOVEREIGN, SHEER PLAN.



∵ *The dotted lines are those of Ships of the present day*

THE ROYAL SOVEREIGN, BODY & HALF BREADTH PLANS.

⁂ *The dotted lines are those of Ships of the present day*



the Dutch were waiting for an opportunity to attack them, Sir John acquainted the commanders of both fleets, that he should stand opposed to that fleet by which the neutrality of an English harbour should be violated.* The Spaniards were the first to fire upon their enemies; and the Dutch admiral, Van Tromp, reminded the English admiral of his declaration, requesting that if he would not join in attacking the Spanish fleet, he would, at least, allow him to do so alone. To the latter part of the message no objection appears to have been made; as Van Tromp immediately weighed anchor, approached the Spanish fleet in order, and cannonaded it so severely, that only ten of their ships ultimately escaped, being either sunk, burnt, stranded on shore, or taken by the Dutch.† In this affair, there is sufficient evidence of the respect paid to the British flag, in the forbearance and conduct of Van Tromp. And this was the last service in which king Charles employed his navy.

The ship-money constituted the means of supporting the navy, whilst the parliamentary function was suspended—a period of eleven years. When a parliament was called in the spring of 1640, a debate was soon brought on, with a view to devise some means of abolishing or superseding that tax; but during the progress of the debate, the assembly was hastily dissolved: this rash step led to much evil. Parliament again assembled on the 3rd of November, in the same year, and obtained the privilege of being indissoluble except by its own consent.

When the civil war broke out in 1642, the possession of the navy became an object of the first importance. The parliament, by one of those bold marks of policy which gave them the ascendant power, got the fleet under their own controul. At this time it was found to have diminished, since 1633, from fifty to forty-two ships, amounting only to about 22,400 tons; this fact is at variance with the statements of the apologists of king Charles, who represent the navy as continually increasing, and improving, during the period in which ship-money was levied.

The earl of Warwick was appointed to the command of the fleet; and other officers were appointed under him, favourable to the parliamentary interest. It is true that, during the civil war, little service was required of the navy; but it was maintained in good order; and a strong squadron was fitted out, and appointed a guard in the channel, every summer; and by this precaution the hope of introducing foreign aid in support of the royalist party was cut off. A vessel loaded with arms escaped from the parliamentary fleet, only by being run ashore.

So long as the earl of Warwick was retained in command of the fleet, that establishment continued faithful to its masters; but when he was superseded by colonel Ramsborough in 1648, a mutiny broke out, and the colonel and those officers who supported his command were put on shore.

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* Rushworth, vol. 3.

† Campbell, vol 2, pp. 194, 8.

Seventeen ships revolted, declared for the king, sailed over to Holland, and submitted to the command of the prince, who made several ineffectual attempts during the short time he was able to retain this fleet, to advance his father's interests. The earl was, however, quickly re-instated; and by a wise course of conduct, he succeeded in recovering the most material part of the revolted fleet.

The parliament appear to have attached great value to the navy, as long as the functions of government were in their hands, and the same importance was attached to the navy under the commonwealth; as the republican government showed the greatest regard to the promotion and increase of naval prosperity. "Independent of those ships which still remained to them as having once formed a part of the royal navy, four first or second rates, and nine or ten third rates, had been added to it before the commencement of the war with Holland."* It has been stated that at the origin of the commonwealth, the country could fit out no more than fourteen ships of war, some of which carried only forty guns; but that within the three years immediately following, the navy so increased, that they could command a fleet consisting of twenty-three ships of the first, second, and third rates, thirty-one fourth rates, and nearly fifty of inferior magnitude. So much energy was developed by the English, even when the whole order of society was deranged.

Sir Robert Slingeby, comptroller of the Navy, states, in his "Discourses touching the past and present state of the Navy," "But since these great distractions became at home (alluding to the times of the Commonwealth), forraigne trade decayed, and merchants so discouraged from building, that there hath been scarce one good merchant ship built these twenty years past, and of what there were then in being, either by decays or accident, there are very few or none remaining; the merchants have found their private conveniences in being conveyed at the publick charge, they take no care of making defence for themselves if a warr should happen." While he states that in the time of Charles the First, "The merchants contiuned their trade during the warrs with France and Spain, if they could but two or three consort together, not caring who they met." At this time, it would appear that the merchant ships were little inferior, either in strength or burthen, to the ships of the Royal Navy. In his Discourses, he recommends, that measures should be taken to check the evil, and expresses much regret at the decay of mercantile shipping, from their importance to the state.

The earl of Warwick was superseded in the command of the fleet in 1649, by Blake, Deane, and Popham jointly, or by any two of them; two years afterwards the appointment was renewed; and in March, 1652, Blake was appointed "sole general of the fleet for nine months."

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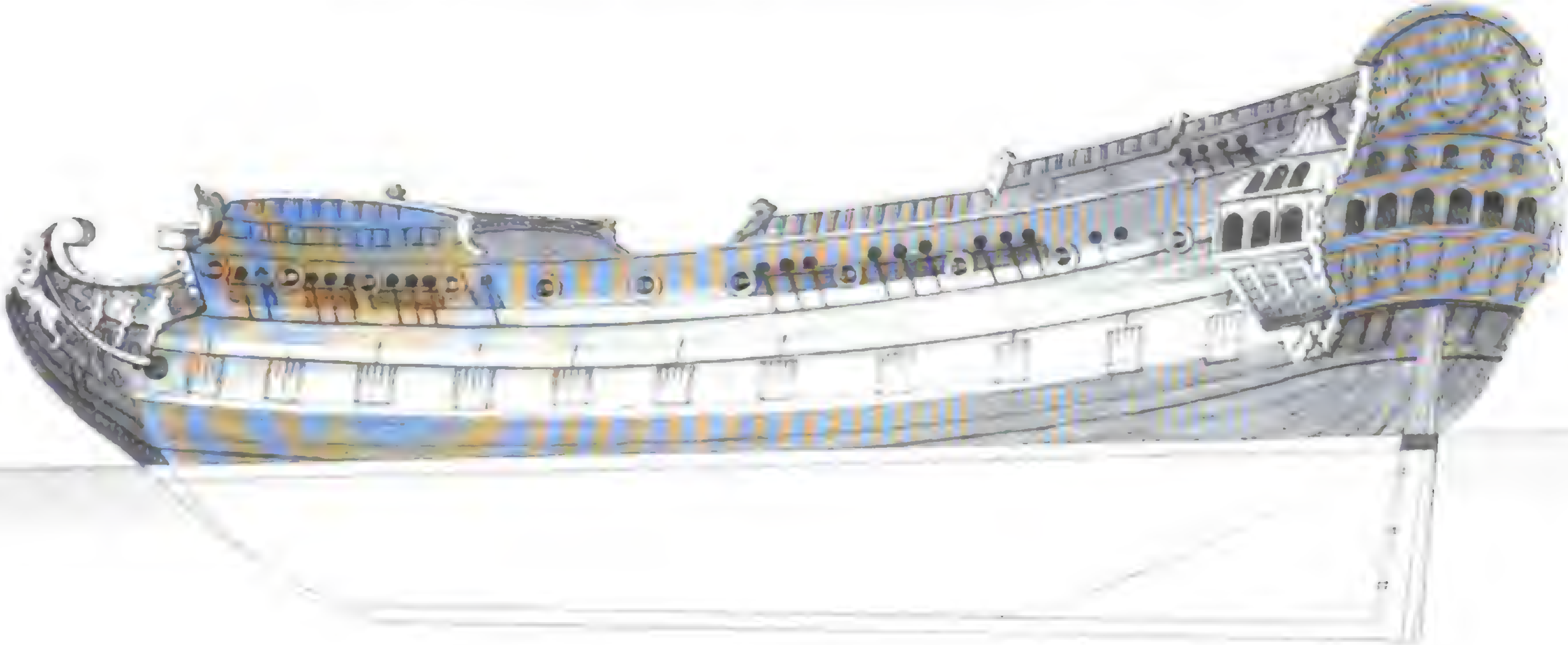
* Charnock, Vol. II., p. 294.

THE SPEAKER, A BRITISH SECOND RATE, BUILT IN 1640.

This Ship bore the Flag of Vice Admiral Penn in an Engagement of three days successively between the English & Dutch Fleets in 1653.



The first Dutch war was declared in July, 1652. There had, however, been a naval engagement between an English fleet and a Dutch fleet two months before. The immediate cause of this engagement appears to have been a jealousy regarding the customary mark of respect to the British flag; but it is disputed whether the English or the Dutch began the action. This was followed by the capture of a squadron of twelve ships of war, appointed to protect the Dutch fishing busses before war was declared. After the declaration of war, it was prosecuted with such indefatigable perseverance, that four general engagements tried the power of both states before the end of the following November, whilst ability and courage were as conspicuous in the last as in the first engagement; and in both fleets alike.

The following list gives the dimensions, burthen, and force of the largest ship in each of the rates, as given in the fifth volume of Pepys's Miscellanies.

Rates.	Names.	Length of keel.	Breadth.		Depth.		Burthen.	Highest No. of	
								Men.	Guns.
		Feet.	Feet.	in.	Feet.	in.	Tons.		
First	Sovereign	127	46	6	19	4	1141	600	100
Second	Fairfax	116	34	9	17	4½	745	260	52
Third	Worcester	112	32	8	16	4	661	180	46
Fourth	Ruby	105½	31	6	15	9	556	150	40
Fifth	Nightingale	88	25	4	12	8	300	90	24
Sixth	Greyhound	60	20	3	10	0	120	80	18

The greatest industry prevailed in refitting and improving the fleets of both England and Holland during the winter; and in less than three months after the last general engagement, in which admiral Blake had sustained a defeat, he was again in command of a strong fleet, amounting to seventy sail, with which he took his station in the channel, to intercept a home-ward bound Dutch merchant fleet, under the protection of a very strong convoy, commanded by Van Tromp. On the 18th of February, the Dutch fleet arrived, consisting of a naval force, it is supposed about equal to that of the English, and between two and three hundred sail of merchant ships. The engagement consequent upon this meeting, occupied such portions of three days, as the fleets could be brought into action: the British admirals reported that in these three days' engagements, they took or destroyed eleven men-of-war, and thirty merchant ships; that they killed about two thousand men, and took fifteen hundred prisoners; and that, although the English ships suffered severely, only one was lost,—which when the captain saw it was impossible to save, he and all his men left her, and she sank; and that their loss in men was about equal to that of the Dutch.

The long parliament, in whose interest the Dutch war had been begun, was dissolved in the spring of 1653; but the war was carried on with vigour by Oliver Cromwell, for several months longer. During the progress of this war the navy increased rapidly; an accumulation of ships of war developed resources for maritime warfare beyond any preceding period; and the energy with which the war was carried on, proved how well the English sustained their national character for courage and naval skill. Great preparations were made for conducting the naval operations during the summer, and the principal fleet intended for the channel service, consisted of ninety-five ships of war, and five fire-ships; the command of which was given to admirals Monk and Deane. Van Tromp, in the command a fleet of about the same number of ships, was the object of their search. The two fleets met on the morning of the second of June, and an action was begun in the course of the forenoon, which was maintained for four hours; but a confusion arising in the Dutch fleet, the admiral was unable to restore order, and therefore maintained a retreating fight till the evening, when one of their large ships blew up.

In the evening of this day, Blake arrived with a squadron of eighteen sail, to reinforce the English fleet; and preparations were made to renew the engagement on the following morning. This was begun about eight o'clock on the third of June; and was maintained with great resolution till noon, when Van Tromp was again obliged to retreat. The loss of the Dutch amounted to nineteen sail, including six of their best ships, taken and destroyed: on the side of the English, but few men were lost, and not a single ship.*

Van Tromp having conducted his fleet into port, became subject to the blockade of an English fleet, which took its station off the coast of Holland. In this state of affairs, negotiations were commenced for the restoration of peace: Cromwell refused to discontinue the blockade whilst the negotiations were pending, and the Dutch exerted their utmost power to restore their fleet to a condition fit for putting to sea again, as they were distrustful of the results of negotiation. Whilst Van Tromp directed the refitting of the fleet that had lately returned from sea, De Witt fitted out a considerable number of new ships, some of which were superior to any that had been previously employed in the Dutch service. By the end of July all the preparations for sea were completed; and the Dutch succeeded by stratagem in leaving their harbours on the 29th of that month, but without coming immediately to an engagement. The next day the state of the weather kept the two fleets apart; but on the 31st the last general engagement in this war was fought; it was conducted with resolute fury, and lasted eight hours. The brave Van Tromp was killed; and this event so affected the Dutch, that they were unable much longer to maintain the action. They retreated, and were pursued; disorder followed, and the loss of twenty-six ships was the result of this action; the rest succeeded in getting into the Texel. Fire-ships were now in use; and it was common for each fleet in these general engagements to be provided with five or six of them; and in this action the English had two ships burnt. The negotiation was revived after this event; but the treaty of peace was not concluded until the following April.

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* Campbell, Vol. II., pp. 261-3.

The British navy was now forthwith put into complete repair, and increased by a considerable number of new ships; and the naval arsenals and magazines were well supplied with stores and ammunition, that the country might be in a situation to exert its energies with effect, should it be again engaged in a war.

The first service in which a fleet was employed after this, was to obtain satisfaction from the grand duke of Tuscany for the injury the English had sustained by the favour he had shown their enemies during the late war, and to punish the piratical states of Barbary for their depredations. Admiral Blake sailed with a fleet of thirty ships for these services; and performed them in a manner that gave to all the states, bordering on the Mediterranean, a just notion of the power of a British fleet.

An expedition was, about the same time, sent out to the West Indies, under admiral Penn, the object of which was to obtain possession of Hispaniola; but failing in this, the attention of the forces was next directed against Jamaica; and the reduction of that island was the fruit of this expedition. This necessarily led to a war with Spain; for no intimation had been given to excite a suspicion that England contemplated any project adverse to the interests of that country. France was united with England in the declaration of war against Spain; and a squadron was sent out to join admiral Blake, who had remained cruising in the Mediterranean or near the Straits, with instructions to intercept and capture the Spanish galleons. This service was partially accomplished, — two of the ships having been captured, two sunk, and two driven ashore, whilst only two escaped.

In 1657, Blake received information that several Spanish galleons had arrived at the Canaries, and were lying at Teneriffe. He proceeded to the island; and notwithstanding the very strong fortifications by which the harbour was defended, he entered, to the astonishment of the Spaniards, and destroyed all their ships. This was the last naval service performed during the war.

Under the protectorate, the navy was so well managed, that, at the death of Cromwell, it consisted of 157 ships; several of the finest of which had been built since the termination of the war with Holland; and forty of them were foreign, most of which were taken in the Dutch war; the whole amounting, according to some statements, to at least 62,252 tons. Within a few years some material improvements had been introduced into the building of ships, especially in the form of the bottom.*

The restoration of monarchy was effected by means of the navy: this was gained over to a compliance with the orders of general Monk, who sailed with it over to Holland, whither prince Charles and his brother James had come. They were conveyed to England forthwith; and arrived in London, on the 29th of May, 1660, where the prince had been already proclaimed as Charles the Second.

When the form of government was settled, James, duke of York, was appointed lord high admiral, and lord warden of the Cinque Ports; and it was estimated that eight hundred thousand pounds would be necessary for the maintenance of the navy and other expenses, which had formerly cost only eighty thousand pounds. King Charles, on his restoration, pledged himself to pay particular attention to the interests of the navy; and during the early part of his reign, a strict regard was had to the fulfilment of his pledge; the navy flourished more than the other establishments of the kingdom, although he at first borrowed money from the city for the purpose of fitting out a fleet.

The wars which occurred during this reign, called into most vigorous exercise all the naval force that could be obtained to serve in them; they also had the effect of increasing the maritime establishments, more than any former exigences of the state. Perhaps no two nations had ever been so well able to carry on a naval war, as England and Holland had been since the middle of the seventeenth century. In the course of the second Dutch war, which broke out in 1665, very large fleets were fitted out on both sides; after the declaration of war, the first general fleet fitted out by England, consisted of a hundred and fourteen ships of war and frigates, and twenty-eight fire-ships and ketches. That fitted out by the Dutch, was composed of a hundred and two men of war, eleven fire-ships, and seven yachts.

The first general engagement was that of the 3rd of June, in which the English gained important advantages over the Dutch fleet, of which, according to the English accounts, fourteen ships were sunk, and several burnt and blown up, besides eighteen which were captured; but several of these were abandoned by their captors. On the other hand, the Dutch admit the loss of no more than eighteen ships altogether.

The employment of the English fleets was directed, with about equal care and diligence, against the commercial and the naval fleets of Holland. On the first of June, 1666, a general engagement began between the English and the Dutch fleets; it was renewed on the second, third, and fourth, and then terminated indecisively. A more decisive action was fought by the fleets of England and Holland towards the end of the following July, in which the English gained an important victory. Great loss was sustained by the commerce of Holland, which the English omitted no opportunity of distressing to the utmost of their ability.

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* Charnock, Vol. II., p. 296.

At this period, while the king was paying attention to the interests of the navy, scientific men had turned their attention to a more systematic mode of construction, and applied their mathematical knowledge to this subject. Thus we find, in Pepys's Diary, 19th May, 1766, "Mr. Deane did discourse about his ship the *Rupert,* which succeeds so well, as he has got great honour by it; and I some, by recommending him. The king, duke, and every body, say it is the best ship that was ever built. And then he fell to explain to me the manner of casting the draught of water which a ship will draw, before-hand, which is a secret the king and all admire in him; and he is the first that hath come to any certainty before-hand of foretelling the draught of water of a ship, before she is launched."

Pepys further states, in 1665, "Another great step and improvement to our navy, put in practice by Sir Anthony Deane, was effected in the *Warspight* and *Defiance,* which were to carry six months' provisions, and their guns four and a half feet from the water."

The English neglected, in the spring of 1667, to fit out a fleet suited to cope with that of the enemy; and the Dutch, taking advantage of this, sailed up to the Nore with a considerable fleet. Early in June, De Ruyter attacked the unfinished fortifications at Sheerness, and then sailed up the Medway as high as Upnor. The *Royal Oak,* a fine ship lying in the river, was burnt; and the hull of the *Royal Charles* was taken, besides such as were either taken or destroyed at Sheerness. The Dutch admiral then sailed round the southern coast of England; but failing in his designs there, he returned, and sailed up the Thames as far as Gravesend, ravaging the country as he chose. A small force, fitted out in the river, and plentifully supplied with fire-ships, proceeded to attack him; and a very liberal use was made of the fire-ships on both sides. When De Ruyter had expended all his, he retired from the river, and returned at his leisure towards the coast of Holland.

Negotiations for peace, which had been begun some time before this affair occurred, were now hastened on to a conclusion, and peace was restored in the following June, though the proclamation of that event was not made in London till August. From this time till the third Dutch war, the navy had but little service to perform, besides that in the war with Algiers, and for this a small fleet was maintained for a considerable time in the Mediterranean.

War was declared against Holland in 1672; and in this war the French, who had now made some advance in maritime affairs, were united with the English. They sent out a fleet of thirty-six ships of war, to join the English fleet of sixty-five men-of-war. At the same time the navy of

Holland consisted of ninety ships of the line, besides forty frigates and fire-ships.* The Dutch fleet was at sea early in May; and on the 28th of that month, when the duke of York, in command of the British fleet, in conjunction with that of France, was lying in Solebay, the Dutch fleet was seen approaching him. His fleet had just time to get out of the bay before the Dutch arrived; a severe engagement was the result, which lasted throughout the day, and then ended indecisively.

The Dutch endeavoured to obtain a restoration of peace; and the English were strongly adverse to the war; but the king and Louis the Fourteenth engaged that neither should make peace without the concurrence of the other. In May, 1673, the fleet was again ready for sea, and was commanded by prince Rupert. The English and French fleets formed a junction, being then about eighty-four men-of-war, besides fire-ships; whilst the Dutch had scarcely seventy men-of-war and frigates. On the 28th of May, and on the 4th of June, two general actions took place, in each of which the victory was an object of dispute.† The last general engagement that was fought during this war was on the 11th of August; but whilst the combined fleet of England and France was materially greater than that of Holland, the result was still indecisive, although the manner in which these three actions had terminated, prevented the landing of an army in Zealand, a principal object that had been contemplated. The circumstances of both England and Holland rendered a peace now highly desirable; Spain became alarmed, and interposed on behalf of Holland; and peace was proclaimed in London, in February, 1674.

From the time the French began to construct a navy, they advanced rapidly in maritime power; and the fleet which Louis sent to act in conjunction with the English, during the last war, was said to have been composed of excellent ships, carrying from sixty to seventy-four guns on two decks. The king and the duke of York went on board of them as they lay at Spithead, and were so pleased with their appearance, especially with that of the *Superbe*, that Sir Anthony Deane was ordered to build the *Harwich* as near to her dimensions as he could. From the plan of this ship, nine others were ordered, by act of parliament, to be built;‡ this was considered to be the greatest improvement made at that time. Too little attention had commonly been paid to the proportions of ships, or rather, the relative proportions were very little understood. Mr. Pepys remarked that "the builders of England, before 1673, had not well considered that breadth only will make a stiff ship," several ships built before that time having been found useless until they were girdled.

It is evident that Charles the Second paid great attention to the details of the navy, which may be seen from the following extract of a letter pre-

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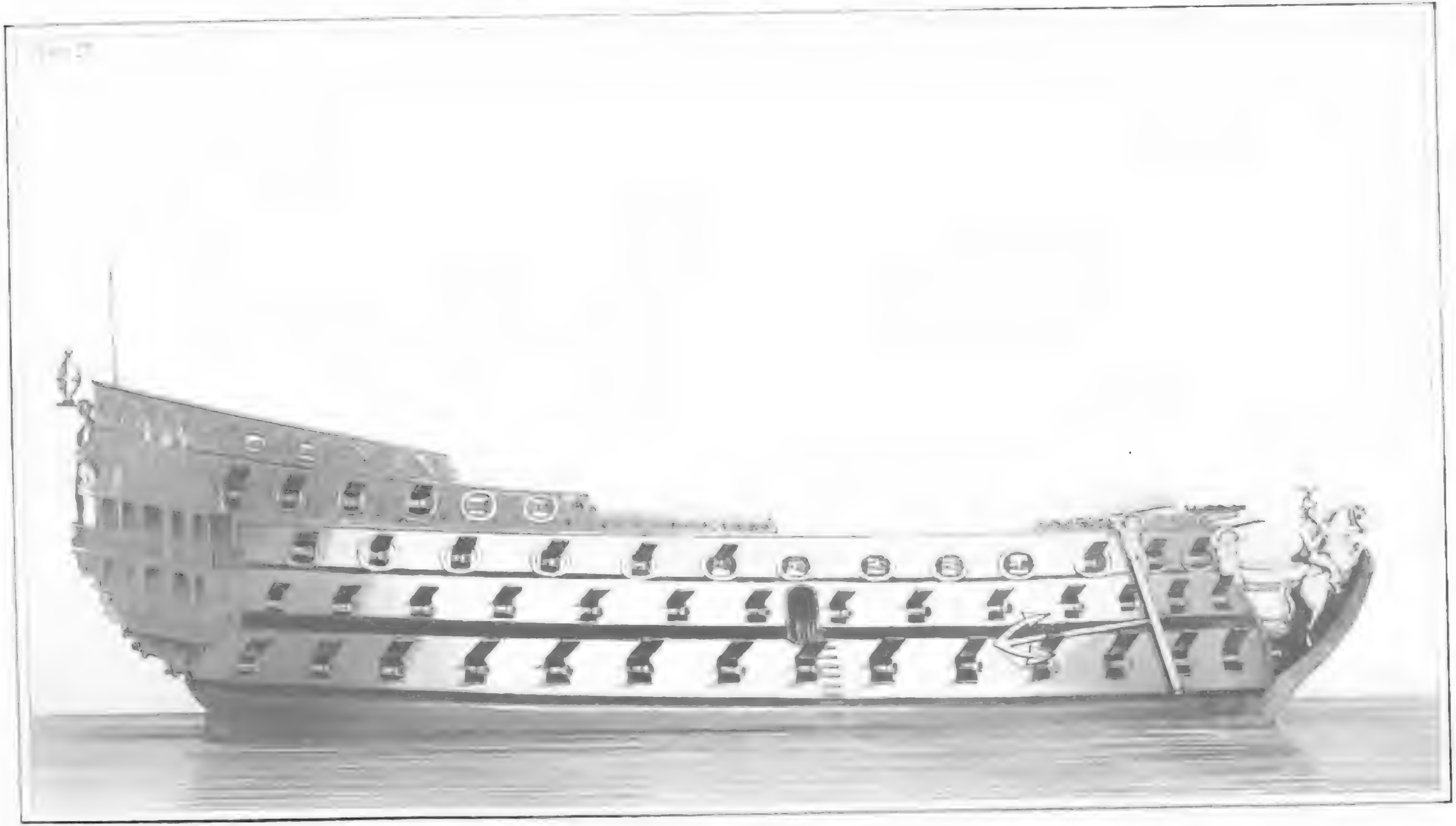
* Charnock, Vol. II., p. 339.

† Burchett, p. 403.

‡ Pepys's Naval Minutes.

THE ROYAL CHARLES, BUILT IN 1673.



served in the State papers, dated 4th August, 1673. "I am very glad that the *Charles* does so well (See *Plate* 17); a girdling this winter, when she comes in, will make her the best ship in England: the next summer, if you try the two sloops that were built at Woolidge, that have my invention in them, they will outsail any of the French sloops. Sir Samuel Mooreland has now another fancy about weighing anchors; and the resident of Venice has made a model also to the same purpose. We have not yet consulted them, with Mr. Tippet, nor Mr. Deane, but hope when they have well considered, we may find one out of them that will be good."

In the year 1675 a statement of the royal navy was laid before parliament, and it consisted then of a hundred and fifty-one ships, &c., as shown, according to their several rates, in the annexed list:

Rates.	Number.	Guns.	Burthen in Tons.
First	8	796	10,800
Second	9	679	8,379
Third	22	1,282	18,427
Fourth	37	1,816	19,767
Fifth	16	500	4,460
Sixth	8	112	1,106
Sloops, fire-ships, yachts, hulks, &c.	51		7,648
Total.	151	5,185	70,587

In the same year the sum of three hundred thousand pounds was voted for building ships, and the duty of tonnage and poundage was annexed to the navy. During the first ten years of this reign, the annual expense of the navy was never less than half a million sterling; and it was stated in the House of Commons, that a less sum than that would be insufficient to maintain it.

From the termination of the third Dutch war, the navy was neglected, and the ships were allowed to go to decay whilst the management of it was in the hands of the king. At length it had become so bad, that in 1679 the king was obliged to grant a commission for executing the office of Lord High Admiral. Two years previously to this, it had been proposed to establish certain dimensions for the building of ships, of the larger classes, according to the following list:—

	100 Guns.		90 Guns.		70 Guns.	
	Feet.	in.	Feet.	in.	Feet.	in.
Length on gun deck . . .	165	0	158	0	150	0
„ of the keel for tonnage .	137	8	—		—	
Breadth, extreme . . .	46	0	44	0	39	8
Depth in the hold . . .	19	2	18	2	17	0
Burthen in tons . , .	1550		1307		1013	

In this year the Commons voted the sum of six hundred thousand pounds for the building of ships. The building of ships was then carried on with considerable vigour; thirty capital ships were laid down, namely, one first-rate, nine second-rates, and twenty third-rates; and eleven of them were launched before the spring of 1679, and the others were in a forward state.*

The navy continued to waste even after the commission had been appointed; and thirty new ships, after having been launched, were allowed to go, in a great measure, to decay. Sir Anthony Deane retired from the commission in 1681, which was not continued after 1684.

Although Sir Anthony Deane had retired from the commission, and the same attention was not paid to the preservation of the navy, we find that the example he had set, of pursuing a systematic course of construction, was still maintained; as Sir Richard Haddock, comptroller of the navy, directed that estimates should be made as to "the number of cubic feet that are contained in the bodies of several draughts to their main water-line, when all materials are on board fit for sailing." The result of the inquiry was voluminous, as the details of all the weights are given, which made up the whole displacement, with many particulars relative to the general equipment of 4th, 5th and 6th rates.† The weights of the hulls given are:—4th rate, 418 tons; 5th rate, 160 tons; and 6th rate, 120 tons: and total displacement with all on board,—4th rate, 851 . 8 tons; 5th rate, 377 tons; and 6th rate, 254 tons;—and their dimensions were as follow :‡—

	Fourth rate.	Fifth rate.	Sixth rate.
Length on the deck	124 ft. 6 in.	103 ft. 9 in.	67 ft. 8 in.
Breadth, extreme. .	35 „ 0 „	28 „ 8 „	23 „ 6 „
Drt. of water afore	14 „ 6 „	12 „ 0 „	9 „ 8 „
Drt. of water abaft	15 „ 10 „	13 „ 0 „	10 „ 8 „

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* Pepys's Memoirs of the Royal Navy, p. 8.

† Charnock, Vol. II., p. 483.

‡ In the treatise on "Naval Architecture," by A. B. Creuze, Esq., page 18, is given a table of dimensions, &c., that had been successively in the possession of Sir Jacob Acworth, Sir Jacob Wheate, and Mr. Edward Hunt; and is now in the possession of Mr. Creuze.

In the month of June of that year, the royal navy amounted to a hundred and twenty-six ships, besides sloops, fire-ships, yachts, small vessels, and hulks.* Twenty-four of these were at sea; the others were lying in ordinary. About this time, the duke of York was re-appointed to the office of lord high admiral. The only employment of the navy during the latter years of king Charles's reign, was in the Mediterranean, where the pirates of Barbary were in the habit of plundering the European traders. The king died on the 6th of February, 1685.

James the Second succeeded his brother; and he wisely directed his attention to the improvement of the navy. A new commission was granted,† and eight out of the twelve commissioners that were appointed, had acted under the former commission. Under a systematic arrangement for the discharge of their respective duties, the repairs of the navy went on successfully, and were almost completed within the two years and a half that the commission lasted, which was until October 1688. The abdication took place in the following December. The navy was not conspicuous in the events connected with the revolution. To a great extent both officers and mariners appear to have been disaffected; so that the faith the king reposed in them was misplaced.

At this time the navy consisted of a hundred and seventy-three ships and vessels, as stated in the following table.

Rates.	Number.	Tons.	Men.	Guns.	Highest value of rigging and sea stores for one ship of each class.
First	9	13,041	6,705	878	£ 5,181
Second	11	14,905	7,010	974	4,296
Third	39	37,993	6,545	2,640	2,976
Fourth	41	22,301	9,480	1,908	2,195
Fifth	2	562	260	60	1,031
Sixth	6	932	420	90	634
Fire-ships	26	4,983	905	218	1,031
Bombs, ketches, smacks, yachts, hoys, and hulks.	39	7,175	678	162	
Total.	173	101,892	42,003	6,930	

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* Charnock, Vol. II., pp. 422-5.

† These were the following persons, viz.: Lord Falkland, Sir, J. Tippets, Sir R. Haddock, Sir P. Pett, Sir J. Narbrough, Mr. Southern, Sir R. Beach, Sir J. Godwin, Sir Anthony Deane, Sir J. Berry, Mr. Hewer, Mr. St. Michael.—Pepys's Memoirs, p. 55.

The subjoined abstract gives the dimensions, burthen and force, of the largest ship of each class included in the above list.

Rate.	Name.	Length.		Breadth.		Depth.		Draught of Water.		Tons.	Men.	Guns.
		Feet.	In.	Feet.	In.	Feet.	In.	Feet.	In.			
First .	Britannia	146	0	47	4	19	7½	20	0	1739	780	100
Second.	Duke . .	—		—		18	9	20	6	1546	660	90
Third .	Burford .	140	0	40	10½	17	3	18	0	1174	460	70
Fourth.	St. David .	107	0	34	9	14	8	16	8	685	280	54
Fifth .	Sapphire .	86	0	27	0	11	0	13	2	333	135	32
Sixth .	Lark . .	74	0	22	6	9	2	9	0	199	85	18

During this reign, the use of bomb vessels was introduced into the navy; ship-carpenters and boatswains were supplied with a regular establishment of stores; and various other improvements in the equipment of ships were carried into effect.

An inquiry was made into the cause of the rapid decay which was observed to have taken place in some ships, with a view to endeavour to procure a remedy for such decay in future. The barking of trees, previously to felling them, was proposed as an experiment; but the revolution, it is supposed, interrupted the course of the experiment; and no other effort appears to have been made to try the effect of it.

The transactions of the revolution which placed William, the Prince of Orange, and Mary upon the throne of England, soon led to a war with France, whither king James had fled for refuge. This war was begun by the supply of French ships and troops to king James, with which he invaded Ireland, in the Spring of 1689. With the exception of an almost immaterial encounter between a small English fleet and this French fleet, nothing memorable occurred at sea, until the battle off Beachy-head, on the 30th of June, 1690. On the 21st of this month, the earl of Torrington had been surprised by the appearance of a fleet which consisted of "eighty-four ships of war, seventy-one of which were of the line," and twenty-two fire-ships: at this time, the fleet under his command was far inferior to that of the enemy. Reinforcements of English and Dutch ships soon however raised it to fifty-six ships of war*; a peremptory order was sent from the queen to engage the enemy at all events, and the consequence was a defeat of the combined fleet by the French.

This year, when king William applied to the parliament for an annual sum to be appropriated to the building of new ships, the Commons promptly complied with his request, and provided accordingly for that expenditure.

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* Charnock, Vol. II., p. 445, Campbell, Vol. III., pp. 59, 61.

Thirty ships were then ordered to be built,—seventeen of 80 guns, of 1000 tons each; three of 70 guns, of 1050 tons each; and ten of 60 guns, of 900 tons each: and, in the next year, a new ordinance was established for the dimensions of 80 and 60 gun ships, viz.:

	80 Guns.	60 Guns.
Length on gun deck..	156 feet 0 in.	144 feet 0 in.
Breadth, extreme....	41 „ 0 „	37 „ 6 „
Depth in hold........	17 „ 4 „	15 „ 8 „
Burthen in tons......	1,100..............	900

The above 80 gun ships were constructed to these dimensions with three decks; and this mode of construction was continued, till the middle of the eighteenth century.

Little was done by the British navy during the year 1691: in the following year the important action off Cape La Hogue was fought, on the 18th of May, and several following days, when the combined fleets of England and Holland gained a great victory over the French; the loss of the enemy amounted to twenty-one ships. The advantage in point of power was decidedly in favour of the combined fleet at this time, admiral Russell having had under his command ninety-nine ships of the line, besides frigates and fire-ships; whilst the French fleet contained no more than sixty-three ships of the line; about thirteen of which were, at the time of the engagement, detached on other service.

The Commons showed their liberality this year, by voting nearly two millions sterling for the maintenance of the navy during the ensuing year, the building of eight fourth rates, and four bomb vessels; and the finishing of Plymouth dockyard.

But little service was performed by the navy in 1693, except the bombarding of St. Maloes, a place from which numerous privateers issued, by which the English trade had suffered severely. At the same time the French were exerting their utmost energies to repair their naval losses, and resent on the English the injury their fleet had sustained at La Hogue. They intercepted a fleet of merchantmen under inadequate protection, and captured several ships of war, and a great number of merchant ships. So strong, however, was the national concern to provide every facility for the fitting out of fleets, and for increasing the number of ships, that the Commons granted the sum of two millions sterling for the service of the navy.

During the following year, the principal employment of the fleet was in the Mediterranean; and the services at sea were more successful than they had been in 1693, although no general engagement occurred. Towards the close of the year, when Parliament assembled, the sum of £2,382,712 was voted for the service of the navy: and in the beginning of 1695, the importance of increasing the fleet was pointed out by the Lords in an address to the King; as they considered it essential to the honour and security of the nation, that its fleets should always be superior to those of the enemy.

The principal events at sea during the summer of 1695, were the bombarding of several towns on the French coast, from some of which privateers were fitted out; but the English commerce nevertheless suffered severely by the part which the privateers still took in the war.

Early in 1696, the navy was called to take a very prompt and decisive course in order to prevent an invasion which the French had made great preparations to attempt for the restoration of king James; which project was effectually defeated. But, for the most part, the affairs of the navy appear to have been ill-conducted; and a parliamentary inquiry was made into the matter, as the squadrons had failed to protect the channel from the depredations of the French. The conduct of the fleet in the West Indies was also most unsatisfactory to the nation. Little else of importance was performed by the navy during the war, which terminated by the treaty of Ryswick, in 1697: the British navy lost, during the war, fifty ships and vessels; and that of France lost fifty-nine.*

After the waste consequent upon so long a war, it was considered necessary to increase the navy in such a manner as should place it in a fit condition to engage again in a war with France. Few ships of the first rate had hitherto been built. "The second rate comprised two descriptions or classes; the largest of three decks, and mounting ninety guns; the second of two decks, and carrying only eighty; these ships were adapted only for particular services, and they were consequently few in number. The bulk of all fleets was principally composed of third rates; ships of two decks, mounting seventy guns in time of war, or when on the home station; and but sixty-two when sent into distant parts.

"Ships of the fourth rate were also considered of the line, but were of inferior consequence, mounting only fifty or forty-eight guns when in the British seas, and forty-six or forty-four when in other parts of the world; but considerable attention appears to have been paid to this particular class of vessels, almost in preference to any other."† Little further service was required of the navy during the remainder of the reign of king William, except that a fleet was sent out on behalf of Sweden.

In 1701 there were very evident indications of approaching war, as the greater part of Europe felt interested in the event of the Spanish succession. Considerable naval preparations for war were made in the summer of that year, and a fleet of English and Dutch ships was sent to the West Indies. The death of the king occurred in March, 1702, previously to any declaration of war having been made. Since the revolution, the navy had increased to a very great amount; and shortly before the king's death it consisted of seven ships of the first rate, fourteen of the second, forty-five of the third, sixty-three of the fourth, thirty-six of the fifth, and twenty-nine of the sixth rates, eight fire-ships, thirteen bomb-vessels, and ten yachts; which together amounted to 158,992 tons, being an increase of 57,960 tons within the last thirteen years.*

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* Burchett, pp. 573-4.

† Charnock, Vol. II. pp. 482-3.

It was about this time that Peter the Great made his extraordinary efforts towards raising a naval power in Russia. This monarch having travelled into Holland for information in ship-building, afterwards visited England with a view to improve his knowledge of the art, by studying the manner of building practised in this country. In order to attain his object he attended at Deptford dock-yard, where "he wrought much with his own hands, and made all about him work at the models of ships."† He received his principal instruction in naval architecture from Sir Anthony Deane, to whom he devoted much of his time and attention.

He appears to have given a decided preference to the English over the Dutch method of building; as he engaged Mr. John Deane, the brother of Sir Anthony, to accompany him to Russia, where his most zealous efforts were directed to the raising of a navy, and not without success. A single instance may be mentioned to show that the Czar had both native ingenuity, and a good insight into the modes of mechanical combinations. This was the invention of a keel for his ships, which was so combined with the floors, that it might be completely destroyed without endangering the ship by the loss of it.‡

At the commencement of the eighteenth century, England possessed about one-third of the whole naval power of Europe; France and Holland together possessed about the same amount, whilst the collective force of all the other states of Europe made up the other third.

The accession of queen Anne to the British throne was followed, on the 4th of May, by a declaration of war against France and Spain, called the war of the *Succession*. The greatest emulation prevailed in France to advance the naval power of that country; England now made a corresponding effort, because, from the condition of the French navy, it was apparent that the approaching war would be to a great extent a maritime contest. Louis the Fourteenth, considering that naval eminence was necessary to the glory of his reign, had been careful to repair the losses which his fleets had sustained in the late war, especially in the battle of Cape La Hogue. The events which occurred during the war, however, showed the insufficiency of France at that time to cope with England on the sea. It is true that Louis aimed not only at repairing his losses numerically, but at producing such superior ships as should possess advantages over those of England. Already the ships of France had been distinguished as superior sailers; and the improvements introduced about this time consisted in giving increased dimensions, without adding to the force; yet, according to the prevailing opinions of those times, the alterations were pronounced to have been carried to an extravagant length. The French ships of three decks, which in 1688, were fifteen hundred tons burthen, were increased, in 1702, to two thousand tons. Spain, in the zenith of her marime dignity, had set the example in that kind of excellence; and England at length approached cautiously in the same line of improvement, applying it to some classes only of her ships; but even in these she fell short of her exemplar, and failed of obtaining the advantage of swift sailing, which throughout the war was seen to be a general defect in the English ships.

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* Campbell, Vol. III., pp. 338-9.

† Bishop Burnett.

‡ See Mr. John Deane's letters to the earl of Carmarthen, 1699.

Extensive naval preparations had been made for carrying on the war; and several fleets were soon sent out to different parts. Sir George Rooke was appointed to the command of a fleet, consisting of thirty English and twenty Dutch ships of the line, and a number of smaller ships and vessels; amounting in the whole to a hundred and sixty sail. He left England towards the end of June, and arrived off Cadiz before the middle of August; but the design against that place was abandoned, after considerable efforts had been made by the troops; and the fleet was proceeding on its return to England, when intelligence having been received, that "thirty French ships of war and twenty-two Spanish galleons" had arrived at Vigo,* the British fleet sailed for that port, and arrived there on the 11th of October. A severe action was fought on the next day, in which the English and Dutch were eminently victorious. Five ships of the line and two frigates were burnt, and ten ships of the line were taken; but four of these bilged. Eleven galleons were also taken (two of these were however on shore), and six were burnt.† By the capture of these galleons, a very large amount of riches fell into the hands of the English and Dutch: the prizes were soon afterwards sent to England under the charge of Sir Cloudesley Shovell.

The English and the French were actively engaged in the West Indies; and in August of this year, admiral Benbow attacked the French admiral Du Casse, off Carthagena. In this engagement several of the English captains neglected to perform their duty, leaving their admiral in a very unequal contest against the enemy. Two of the captains were, on their return to England, shot for cowardice.

Cruisers were kept employed in the European seas, where they occasionally made prizes of French ships, both naval and commercial. The *Hazardous*, a fifty-gun ship, which was captured by a British squadron, was of superior dimensions to those of sixty guns in the English service.

Early in the year 1704, Sir George Rooke sailed with a fleet to Lisbon; and after having performed the service he was immediately sent upon, and endeavouring to prevent the junction of the Toulon and Brest fleets, he sailed for Gibraltar, and arrived there on the 21st of July. The attack on that place commenced at the break of day on the following morning, by a heavy cannonade; and troops were landed to prevent the garrison from being re-inforced by land. The cannonade was continued with great severity, and when a landing was effected, the Spaniards retreated from their fortifications; and on the 24th of July the governor capitulated. Thus did the strong fortress "that fifty men might have defended against as many thousands," it has been said, fall by the gallantry and intrepidity of British seamen. This place was immediately garrisoned by such troops as could be spared for that service; and the fleet sailed from Gibraltar on the 9th of August; and that fortress, having subsequently withstood several attacks of France and Spain, even to the defiance of the greatest armament that was ever brought against a fortress, remains a splendid memorial of the prowess of the British character.

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* Burchett, p. 625.

† Ibid, pp. 227-8.

A general engagement took place between the English and French fleets a few days afterwards. The French fleet consisted of fifty-two ships, seventeen of which were three-deckers, and twenty-four galleys: the English and Dutch combined fleet consisted of fifty-three ships. On the 13th of August the two fleets came within three leagues of each other, and the French having formed the line, began to manœuvre for advantage. It was then deemed important to begin the action as soon as possible; and at ten o'clock the English bore down and began the engagement. It was maintained for a considerable time with vigour on both sides, and then terminated; the loss on the side of the French being one ship of three decks, four of two decks, and a few galleys. After the two fleets had repaired their damages, the English endeavoured for several days to renew the action, but without effect, as the French retired to Toulon; and during the continuance of the war they never again ventured on a general engagement. The combined fleet sailed, shortly after this, for Gibraltar, and Sir George Rooke then returned to England. Strong efforts were now made to compel the English garrison to surrender Gibraltar; the siege was undertaken, and carried on by France and Spain.

The British navy had so much increased in magnitude after the revolution, that it became important that economy should be regarded in building and repairing the ships which composed it; and in the year 1694, a general order was issued, prohibiting any unnecessary expense in the dockyards. In 1703, a more particular order was given for diminishing the expense in building and re-building ships of war. This order was the result of deliberations in the council of prince George of Denmark, at that time lord high admiral of England; and it related to the ornamental work with which it was customary to decorate both the inside and outside of ships of war. The display of ornamental work had grown with improvement in ship-building; and the *Sovereign of the Seas* (*Plate* 15,) had been conspicuous for the elaborate ornament with which she was finished. But now, as the necessary expenses of a large naval establishment increased, it was ordered that the carved work should be diminished; and that the ornaments at the head should consist of only a lion and a trail-board, with mouldings instead of carved brackets placed against the timbers; and that the excessive ornamental work of the stern should be discontinued; and only a taffrail and four-quarter pieces used instead of the brackets between the lights of the stern galleries. The heavy ornamental lining against the inside was ordered to be discontinued in ships to be subsequently built or rebuilt; and its place supplied by a plain lining of slit deal, without any moulding or other ornament. And the standing cabins were to be no longer formed of framed and panelled bulkheads; but were to be formed of frames covered with painted canvas. These and other alterations were now ordered to be made, with the direct view of diminishing the expense in building and rebuilding ships of the first, second, and third rates.

During the years 1705 and 1706, the war was carried on with considerable vigour; and the fleets in the Mediterranean rendered material service in counteracting the designs of France, whose armies were in Spain, and whose squadrons watched the opportunities to assist the military in the absence of the English fleet. The fleet in the West Indies did very little towards advancing the objects of the war; whilst the British commerce was much injured by the enemies' cruisers.

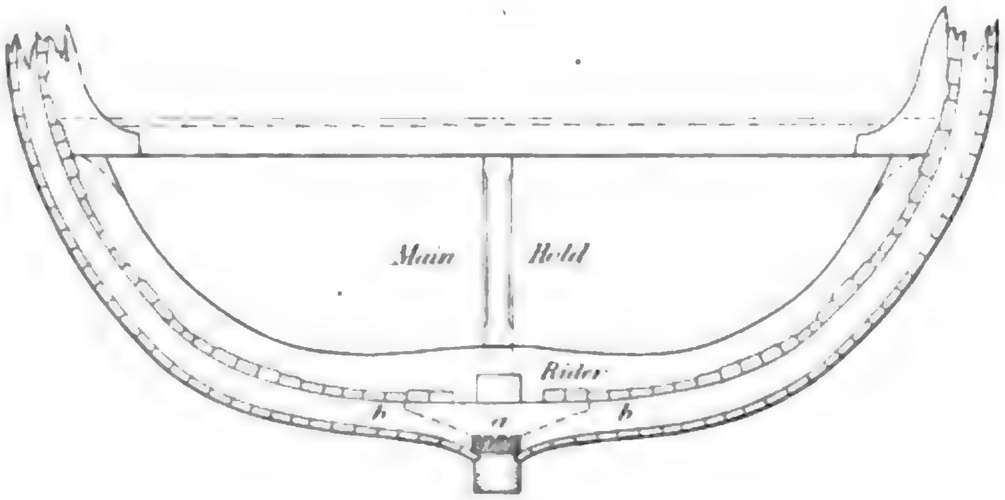
In the year 1706, an order was given, establishing the dimensions of ships according to the following list.

	90 Guns.		80 Guns.		70 Guns.		60 Guns.		50 Guns.		40 Guns.	
	Feet	in.	Feet	in.	Feet	in.	Feet	in	Feet	in.	Feet	in.
Length on gun deck . .	162	0	156	0	150	0	144	0	130	0	118	0
Length of the keel for tonnage	132	0	127	6	122	0	119	0	108	0	97	6
Extreme breadth . . .	47	0	43	6	41	0	38	0	35	0	32	0
Depth in the hold . . .	18	6	17	8	17	4	15	8	14	0	13	6
Burthen in tons. . . .	1551		1283		1069		914		704		531	

This was some improvement in the inferior classes of ships; but the English were still behind the French in the dimensions of their ships in relation to their armament, and in that form of the bottom which renders a ship a good sailer. The French ship *Maure* of 60 guns, which was captured during this war, was found to be of much larger dimensions than English ships of the same force: she had been constructed with special regard to her adaptation for service at sea. The English ships which happened to be captured by the French, and were afterwards retaken,

ALTERATIONS MADE BY THE SURVEYORS OF THE NAVY.

Fig. 1.



Original Plan of allowing
the 1st Futtocks short.

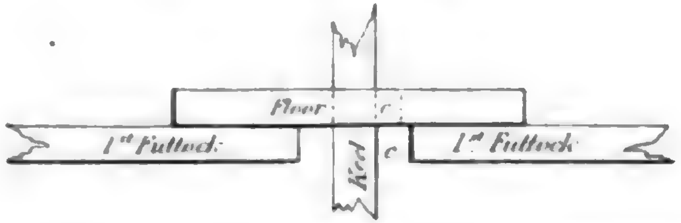
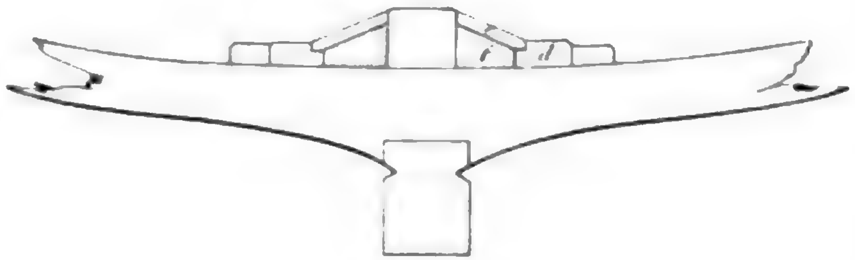


Fig. 2.



were found to have been reduced to a considerably inferior armament, an instance of which is given in the *Pembroke* of 64 guns, which was captured by the French, and reduced in their service to 50 guns.*

The superiority of French ships in point of sailing was generally perceived. Perhaps no instance occurred during the war which pointed out more clearly and fully the advantage the French gained by this superiority of their ships, than that in which their admiral, Count de Forbin, with a very small squadron, was chased by Sir George Byng from the Firth of Edinburgh, in March, 1708. The object of the French was to effect an invasion of Scotland on behalf of the Pretender; and the information which was received of the designs contemplated by France, led to the fitting out of a fleet to defeat this attempt. When Sir George Byng had ascertained the fact of the French squadron having sailed, he followed it, and gained sight of the French as they were lying in the Firth of Edinburgh. The Count de Forbin immediately got under way, and by the superior quality of his ships he succeeded in escaping from a fleet of forty ships of the line, besides frigates and fire-ships. And, generally, when any English-built ships were in the French service, and were chased by the English, it was remarked that they were sooner come up with than those of the French build,—as the *Salisbury* and *Blackwall* of 50 guns, and the *Deal Castle* and *Squirrel* of 24 guns; and likewise the *Warwick*, *Ardent*, and *Alexander*. The French ships were also generally found to hold a better wind than the English, and to excel them in beating off a lee shore.

With numerous examples before them, the English naval architects failed of making the advance which, under these circumstances, was highly desirable. Probably this was owing as much to the injudicious interference and restrictions of those who had no skill in the science, as to the want of a due combination of science with the practice of building.

In August, 1710, the surveyors of the navy proposed, that with the view to diminish in the lower parts of ships the injurious effects of bilge-water, the dead wood should be made to run through the whole length of the ship, by working a piece of thickstuff on the upper part of the keel between the fore and after rising wood, of such a breadth that the garboard strake might bed against it; and particularly, to prevent the bilge-water from accumulating between the heels of the timbers at the middle line, as the first futtocks were left short (a practice continued until recently in mercantile ships, and to the present day in some merchant and foreign ships), cross chocks (*a*,) were introduced, scarphed on the heels of the first futtocks, (*b*,) as shown in *Plate* 18, *Fig*. 1. The limbers (*c*,) at the lower part of the timbers were enlarged to give a better passage for the bilge-water to the pumps; and the space between the *limber* strake and the keelson (*Fig.* 2,) was covered over with boards, so as to form a trunk (*c*,) or passage for the water to pass, without obstruction to the pumps. This strake, (*d*,) these boards, (*e*,) and this passage, (*f*,) are now called the limber strake, limber boards, and limber course. Small openings were, however, preserved between the timbers, that by the rolling of the ship the water might enter them and agitate the air in these openings; an effect which, as a degree of ventilation, was at that time deemed conducive to the preservation of ships from decay.

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* Charnock, Vol. III., p. 18.

During the continuance of the war, Great Britain employed her fleets with considerable, although a fluctuating advantage. In the Channel, in the Mediterranean, and in the West Indies, her fleets and squadrons were almost constantly in active service. The light squadrons of French ships at various times made prizes of English cruisers, as well as of commercial shipping, of which the loss was sometimes very severe. The navy sustained some very heavy losses during this reign, by accidents and by gales; and the progress of building, together with the addition of prizes captured during the war, was not equal to the waste the navy sustained. For although the loss of thirty-eight ships, mounting 1,596 guns, was not great for the long period of ten years of hard maritime warfare, yet these losses, added to the necessary wearing out of ships, reduced the number of ships in the navy to two hundred and forty-seven, being a diminution of twenty-five. The number of ships that had ceased to be serviceable in the navy, during this reign, must therefore have been great, as the loss the French navy sustained during this war amounted to fifty-two ships, mounting 3,094 guns, no inconsiderable portion of which fell into the hands of the English. But although the British navy had diminished by twenty-five ships, yet the tonnage of it had increased by 8,199 tons during the reign, making a total of 167,219 tons, as the navy stood at the time of the queen's death; this increase was owing in part to the greater breadth that was given to ships built according to the establishment of 1706, and in part to the larger dimensions of the ships taken from the French.

Few events with regard to the condition of the navy occurred after the long war, which was followed by the treaty of Utrecht, in April, 1713, during the remainder of queen Anne's reign, which closed on the 1st of August, 1714.

When George the First ascended the throne of Great Britain, the navy was not only in a diminished state, but the ships which composed it were in great want of repair; the attention of the government was directed for several years to the raising of the navy to an efficient state, by granting considerable sums annually for the repairs of ships.

The injurious effects of bilge-water and foul air in the holds of ships came under consideration in the year 1715; and instructions were given with the view to diminish the injurious consequences of these elements of decay. The means ordered to be used, consisted chiefly in making such alterations as would allow a better circulation in the hold, permit the water to run freely to the pumps, and allow the fresh air, which might be introduced into the hold, to be diffused with less obstruction. These instructions were given with immediate reference to ships in ordinary; but some of the arrangements were suited to ships at sea as well as to those lying in harbour: particularly the trunk which was ordered to be fitted to the lower deck, to convey the air through the openings of the decks into the hold.

In 1719, when the preservation of ships was again brought under consideration, the master-shipwrights of the several dockyards proposed that about seven feet of water should be let into ships' holds by means of pipes or plugs through the bottom, in the month of April, and remain in till August, that it might produce a general coolness in the hold, and preserve the fore and after bodies, which were seldom impregnated with bilge-water; and that after the water had remained in the ships about four months, it should be pumped out. It was recommended that the experiment should be made upon the ships which had been recently built or rebuilt. But it does not appear that this means was ever extensively used in the navy; or if it was, that the use of it was anything beyond an experiment. It may, however, be supposed that the experiment was made; as particular instructions were given, that the water should not be admitted into ships lying in such positions in the harbours, that they were in danger of taking the ground.

They also proposed that the principal strakes of both the outside and inside planking should be snail-creeped, or guttered or grooved by a gouge to about an inch in breadth, and half an inch in depth. This was found at the breaking up of several ships, to have been done; but the practice was soon discontinued, like the absurd practice which had been resorted to in the seventeenth century, of forcing water against the inside planking below water to discover leaks; but which was never productive of any beneficial result.

A consideration of the general inferiority of British ships of war in comparison with those of France, led to the ordering of a new establishment, in 1719, for the dimensions of ships. By this establishment, ships of one hundred guns were increased nine feet in length, four feet in breadth, and 319 tons in burthen; those of ninety guns, two feet in length, two inches in breadth, and 15 tons in burthen; those of eighty guns, two feet in length, one foot six inches in breadth, and 67 tons in burthen; those of seventy guns, one foot in length, six inches in breadth, and 59 tons in burthen; those of sixty guns, one foot in breadth, and 37 tons in burthen; those of fifty guns, four feet in length, one foot in breadth, and 51 tons in burthen; the forty gun ships, six feet in length, one foot two inches in breadth, and 63 tons in burthen. The following dimensions were also now established for the building of twenty-gun ships: length on the gun-deck one hundred and six feet, length of keel for tonnage, eighty-seven feet nine inches, extreme breadth twenty-eight feet four inches, depth in the hold nine feet two inches, and burthen 374 tons. In the alterations introduced by this establishment, a greater relative breadth was given, making the length of the three-deck ships 3.5 times their breadth; the length of two-deck ships, of seventy and sixty guns, was about 3.7 times their breadth; the length of two-deck ships, of fifty and forty guns, was about 3.75 times their breadth; and the length of the twenty-gun ships was 3.74 times their breadth; the depth in the hold was also increased in every class of ships except those of seventy guns.

Besides the alterations in the dimensions of ships, some improvements were made in their interior conveniences, one of which was, the building of sail-rooms between the fore and main hatchways a-midships. For before this time, the situation in which the sails had been stowed, had allowed them to get damp, and become injured by mildew.

The preservation of timber used in the building of ships was reconsidered this year. Up to this time, thickstuff and plank were generally prepared for use by being charred; the process of charring consisted in subjecting the inner surface of the plank, &c., to the action of fire kept up by bavins, or old timber, whilst the outer side was kept wet. This was continued until the plank was reduced to such a state that it might be bent to suit the purpose for which it was required. And in connection with improving the condition of timber for immediate use, it was ordered that those means should be employed which were best suited to improve the durability of the timber. The same subject had been brought under the notice of the navy board in the years 1694, 1697, 1703, 1704, 1715, 1716, and 1717. The charring of thick-stuff and planks was now partially superseded by the process of stoving. This process consisted in placing the thickstuff and planks in wet sand, and subjecting it to heat of such a degree and for such time as were deemed the best suited to extract the remaining juices of the wood, and to bring it to the condition of suppleness that was required in using it.

The preparation of timber for use, and the preservation of it, were again brought under the attention of the navy board, in 1726, when a report by two of the master-shipwrights on the state of the planking on the bottom of the *Falkland*, which had been rebuilt in the years 1719 and 1720, supplied the means of judging of the comparative merits of different means which were then used for the same purpose. The planks which had been used on the bottom of this ship had been prepared for use by different processes. Some of them had been charred; others had been stoved; and some of them had been neither charred nor stoved: and whilst the planks which had been stoved were found in a state of good preservation, many of those which had been differently prepared were rotten. The different states of the planking of this ship determined the recommendation of the master-shipwrights who surveyed her, and the order which was issued in pursuance of such recommendation.

The practice of stoving timber owed its origin to a Mr. Cumberland, to whom, as a compensation for his useful discovery, was granted a tenth part of the saving which should result from the use of it. But it does not appear that he pursued his investigations very vigorously, or to more than general results; for when the practice was introduced generally into the royal dockyards, the instructions stated that the planks and thick-stuff were not to be kept too long in the heat; and the degree of subjection to the process, and the time of it, were to be ascertained by experiments in performing that service. Salt water and salt water sand were considered preferable to fresh in improving the durableness of the timber; and they were therefore ordered to be always used for this purpose. This means of suppling and improving the condition of timber remained in use until 1736, when it was superseded by the use of steam-trunks, which, in effect, were similar to the present steam-kilns.

A Mr. Boswell, purveyor of timber in the dockyard at Deptford, was the first to introduce the method of suppling timber by steam. This practice was continued in the dockyards about eight years; and was then succeeded by the use of kilns, in which the thick-stuff and planks were boiled as they are at present. The steam-trunks or kilns have, however, been continued in use to prepare the wood for boat-building up to this time; as they have also for more general purposes in private yards; and the more extensive use of them was partially restored in the royal dockyards in 1839. The preparation of the wood by steam is doubtless superior, when the kilns are properly made and managed, to that of boiling it; since the extreme tenuity of the steam renders it capable of penetrating more effectually through the pores than water; and the process is conducted at a less expense.

There were several interruptions to the tranquillity of Europe during this reign, especially the war with Spain, which lasted from 1718 to 1721; causing the frequent employment of fleets and squadrons, for the purpose of obtaining those concessions which were deemed just to the allies of Great Britain, as well as requisite for securing a proper regard to the interests of the English themselves. In 1720 Gibraltar was attacked by the Spaniards; but the intervention of an English squadron defeated their objects, and saved the garrison.*

In 1727 a considerable force was fitted out, and sent into the Baltic to prevent Russia, which had now become formidable in the north of Europe by the growing power of her navy, from involving the northern nations in a war, by an aggressive interference with Sweden. Sir John Norris, in command of the fleet, arrived in the Sound on the 11th of May. The death of the king occurred on the 10th of June, and no other important events resulted from the naval preparations which had been made.

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* Lediard's Naval History, Vol. II., p. 901.

The reign of George the Second was begun with a general peace; Sir Robert Walpole being retained in office, it was the object of that minister to maintain the same national relations. This he was enabled to accomplish for a considerable time, but not without great expense; for, having little confidence in the pacific temper of the continental nations, he did not deem it safe to relax the measures which would hold the nation in readiness to engage in war, whenever such a course should be seen to be unavoidable; and therefore the extent to which a navy was kept ready for service, occasioned a heavy continuous expense.*

The Spanish Guarda-costas in the West Indies, by the rigour with which they enforced the searching of English ships, notwithstanding complaints and remonstrances to the court of Spain, at length provoked the English to enter on hostile measures, to resent the injuries their commerce had sustained. Contrary to the temper of government, the nation appeared eager for a Spanish war; and captain Vernon declared, in the House of Commons, that he would take Porto Bello with six ships of war. A squadron of ships was accordingly fitted out; and Vernon, now promoted to the rank of rear-admiral, was appointed to the command of it, for the service which he had suggested. The result of the attack on Porto Bello was eminently successful; the impetuous bravery with which it was conducted, surmounted every difficulty.

A Spanish war now became inevitable; and it was accordingly declared, in October, 1739. The British navy consisted at that time, of "thirty-eight ships of the line actually in commission, namely: one of ninety guns, five of eighty, twelve of seventy, and twenty of sixty, exclusive of nineteen ships of fifty guns, and twenty-seven vessels of inferior rates, none of which carried less than twenty. Independently of these, twenty-four other ships of two and three decks, two mounting 100 guns each; as many ninety; six, eighty; four, seventy; and ten, sixty or fifty; besides eight frigates, were ready at a moment's warning for immediate service.† But as the war was undertaken in opposition to the views of the government, it was not at first carried on with much of either vigour or success; and even Vernon, whose first enterprise had been so eminently successful, failed to sustain, by a continuance of such conduct, the reputation his service at Porto Bello had acquired for him. A plan was formed, for the taking of Carthagena, for which a considerable re-inforcement was sent to join him; but success was soon rendered hopeless, by the division which arose in the councils of the officers.

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* In 1735, the earl of Northumberland built a ship in Deptford dock-yard, of 950 tons. The king, who attended the launch, named her the "Scourge of Malice."—*Naval History, by Thomas Lediard*, note c., page 28.

† Charnock, Vol. III, pp. 106-7.

In September, 1740, commodore Anson undertook his celebrated voyage round the world: his squadron consisted of five men-of-war, a sloop, and two transports. After entering the South Seas, he became subject to many difficulties in continued succession; perhaps greater than any that had tried the fortitude of a British commander, since the time of Sir Francis Drake. The commodore was deprived of the co-operation of his companions; but after all the ships of his squadron had been separated, he alone, in the *Centurion*, accomplished the greater part of those services which distinguished his voyage,—the plundering of the Spaniards of very large amounts of treasure; and then returned to England, arriving at Spithead, in June, 1744.

No declaration of war with France had been yet issued; but the French and Spanish fleets, lying together in the harbour of Toulon, had been for a considerable length of time blockaded by an English fleet. Early in the month of February, the combined fleet left the harbour, and a very partial engagement took place: the French appear to have aimed at avoiding an engagement altogether; but the Spanish ships, not sailing so well, were attacked by some of the English; and the result of this was, the capture of the *Poder*, a Spanish sixty-gun ship, which, as it was found to be impracticable to bring her off, was set on fire. The English chased the fleets of France and Spain during the following days, without advantage, and then returned to resume their station off the coast of Italy.

Within a short time from this trivial encounter, France issued a declaration of war against England; and in a few days afterwards, this declaration was echoed in England. At this time, says Campbell, "the navy of France consisted of forty-five ships of the line, sixty-seven frigates, and fifty-five galleys; that of England, of ninety ships of the line, eighty-four frigates, and fifty other vessels: in all, two hundred and twenty-four ships of war."†

Since the resignation of Sir Robert Walpole, in 1742, some alteration had been made in the employment of the navy; and now, that a war with France had commenced, another squadron was sent out to re-inforce the fleet in the Mediterranean; but, having on its passage out, put into the port of Lisbon, it was blockaded there for some time, by a fleet which had been sent from Brest for that purpose. The blockade was discontinued when the approach of an English fleet was announced. In the month of October of this year, the *Victory*, of 100 guns, with admiral Sir John Batchen on board, was lost, it is supposed, upon the Caskets; for no certain information was obtained respecting the loss of this ship.

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* Vol. IV., p. 484; see also Charnock, Vol. III., p. 114.

Since the declaration of war, up to this time, the affairs of the navy appear not to have been conducted with sufficient energy; little was accomplished by the fleets generally; and the interests of commerce seem to have been most inadequately protected. The naval administration now gave great dissatisfaction to the country; and in 1745 the duke of Bedford was appointed to the office of First Lord of the Admiralty. This change was immediately followed by such activity as the state of the service at that time required; the West Indian fleet and the Mediterranean fleet were suitably re-inforced; and the British coasts were secured by cruisers properly stationed.*

The naval service was still, however, carried on rather languidly during that and the following year. In the spring of 1747, admiral Anson, having been some time before appointed to the command of the channel fleet, was ordered to attack a fleet that was expected to sail shortly from Brest. Anson had waited some time, and on the 3rd of May the French fleet appeared. The French endeavoured to escape, but were chased; and after an action of about three hours they struck. A fleet of merchantmen was intercepted by an English squadron, in the course of the summer; and about forty sail captured, the convoy having forsaken them to save themselves; and subsequently, a fleet of outward-bound merchantmen from Rochelle was intercepted by a fleet under rear-admiral Hawke; six of the ships of war were captured; and having accomplished that, the admiral did not think it safe to pursue the merchantmen.

In this year an unusual accident occurred in the dockyard at Chatham, in attempting to launch the *Newark*, an 80-gun ship. This ship having passed about forty feet down the slip, stopped, and remained in that position until the next day, when efforts were made to complete the launching of her by the use of screws, tackles, and hawsers; but she remained firmly fixed in the place where she had stopped. On the following day additional forces were applied; but in consequence of an accident, the attempt was discontinued; and as the tides were falling off, means were taken to secure the ship, that she might remain in that position until the next spring tides. In the mean time the state of the ship was carefully examined, when it was found that the launching ways of the slip had settled, which circumstance occasioned the difficulty in launching the ship. The declivity of the slip was then increased, and, at the recurrence of the spring tides, the ship was moved about the distance of ninety-seven and a half feet, when she stopped again; forces were again applied, and the ship was moved by them the distance of about one foot only. On the following morning, at high water, the efforts to launch her were repeated, but without success; and the ship remained stationary until the tide had ebbed about two hours, when she launched into the river without any

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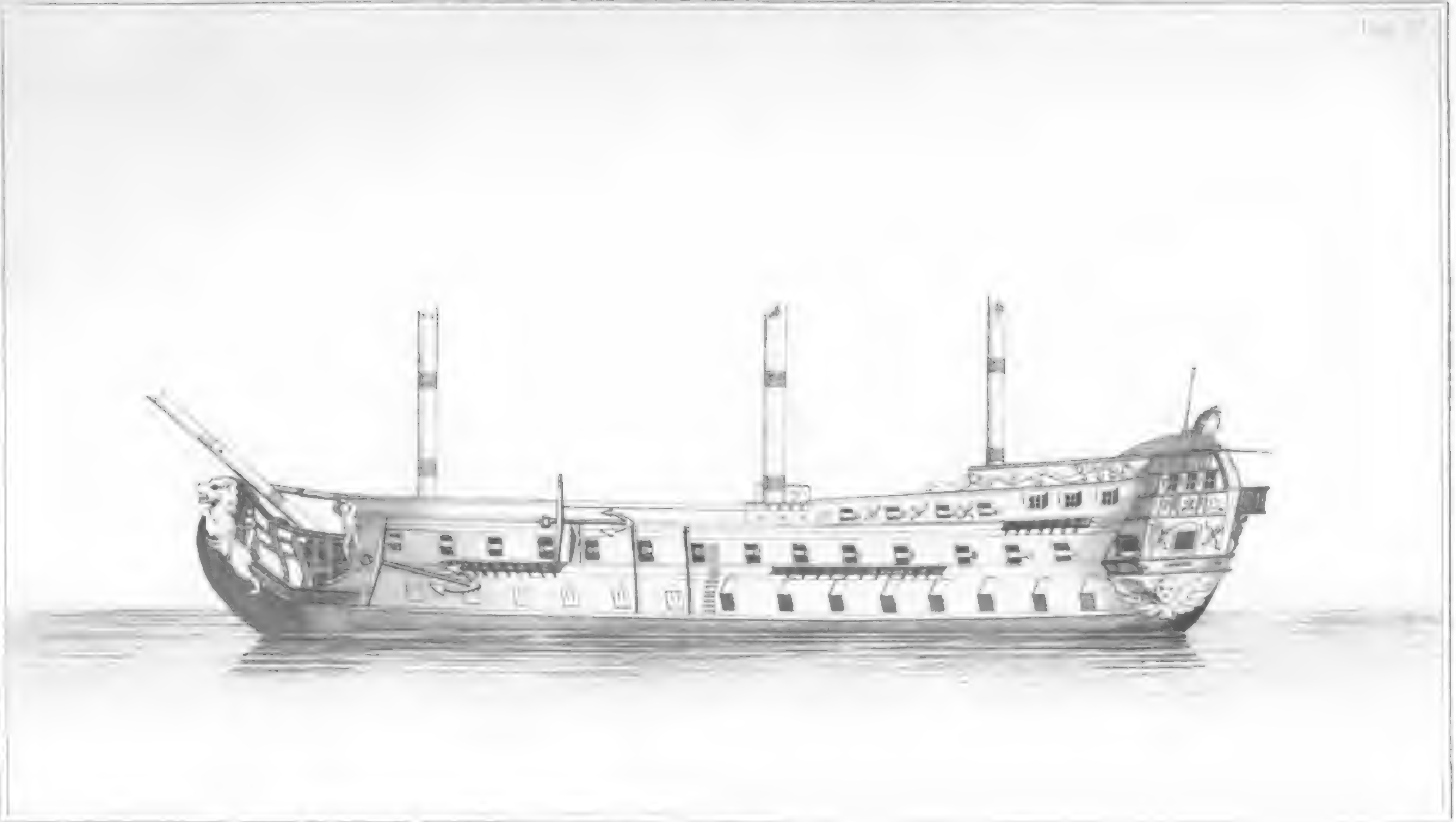
* Campbell, Vol. IV., p. 489.

THE GLORIOSO, A SPANISH 74 GUN SHIP,
Captured by the Russell, Captain Buckle, in September, 1747.



external impulse, the circumstance being witnessed by only the few men who had been ordered to remain in attendance at the ship. The *Newark* was afterwards found to have been strained a little; but she did not leak.

The war terminated in 1748; and from its commencement till its conclusion, the English lost 3238 ships and vessels. The ships and vessels they had captured during the same period were 1249 Spanish, and 2185 French. Of the French navy fifty-six other ships were either taken or destroyed; and of the Spanish, twenty-four. England likewise sustained the loss of sixteen ships, none of which was less than forty guns; seven ships of twenty guns; and twenty-six of inferior rates.

During the naval operations of the war, the English saw the comparative defects of their own ships. The English navy was, in fact, in a very bad condition as it regarded the building of ships. The establishment of 1719 had not been adhered to for some years, and no other had been substituted in its room; ships were then built without any particular reference to a fixed standard, and a great number of the same class were built with various dimensions, without benefit to the service, whilst much inconvenience resulted from this variety.

Complaints had been made too of weakness in ships at sea; and this defect had been partially remedied in pursuance of an order for that purpose, by placing on the different decks as many standards of either wood or iron as could be conveniently placed clear of the guns, and putting additional bolts of larger size than had been ordinarily used for that purpose, as high up as possible in the throat of the hanging-knees. At the same time it was ordered that the beams of the quarter-deck and roundhouse should have the support of lodging knees; and that several of the beams should have, in addition, hanging-knees of wood or iron. The taffrails and quarter-pieces, which were very heavy, were reduced in size; the stem was strengthened; the mainpiece of the knee of the head was lengthened; and additional cheeks were given to the head.

It was "likewise observed, that the scantlings of his majesty's ships in general were not so large and strong as they should be; and it was also a general complaint that the ships were crank, and heeled so much in blowing weather, that they could not open their lee-ports; at the same time that the ships of some other nations went upright with all their batteries open, and ready for action. It was therefore esteemed a matter of the highest importance, that the great inconvenience arising from the loose and irregular manner of building his majesty's ships, which then prevailed, should be rectified, and the complaints so often made of their bad qualities prevented; that the dimensions of the ships in the navy should be brought to a certain size and standard, according to their several classes; that in doing this, the opinion and advice of the master-shipwrights of his majesty's several yards, and of such others as the lords commissioners of the admiralty judged qualified, should be taken, in order to come at a general fixed establishment."*

The objects which were required to be attained, were, that the ships of the royal navy might be enabled to carry the number and nature of guns according to the establishment of that time, having their lower tier six feet above water, with four months' provisions on board, and stores for foreign service: and it was also desired, that other considerations should be comprehended, with a view to give them the proper qualities of good ships of war, in point of sailing, fighting the enemy, durability, and in all other respects whatsoever. The admiral immediately applied to the most experienced and skilful men; and in accordance with the requisition of the admiralty, dimensions were supplied for ships of 100, 90, 80, 70, 60, 50, 40, and 20 guns, and for sloops, by the master-shipwrights of the several dockyards.

"Reform, however," says Charnock, "went on but slowly. The British navy was reduced to an inequality with respect to that of the different foreign powers, reckoning ship for ship, not only in the contracted dimensions, but in the form or shape given to the vessels composing it; which neither the inconveniences found to result from them, nor the example of those benefits found to be derived by other countries, from the pursuit of a contrary system, were for many years capable of removing. This prejudice appears to have risen almost to a species of mania; so that nothing short of the most violent remedies, and coercive regulations, seemed capable of removing the hindrance to improvement."†

One step in the path of improvement resulted from the capture, in 1740, of the *Princessa*, a Spanish ship of seventy guns (*See Plate* 15). The excellence of this ship it was desired to equal; and with this view the *Royal George* was constructed, and laid down at Woolwich, in 1746; but she was not launched until 1756.

The following are the principal dimensions of the *Princessa*, and of the *Royal George*. (*Plate* 16.)

	Princessa.	Royal George.
Length on the gun-deck........	165 ft. 1 in.	178 ft. 0 in.
Length of the keel for tonnage ..	130 „ 3 „	143 „ $5\frac{1}{2}$ „
Extreme breadth..............	49 „ 8 „	51 „ $9\frac{1}{2}$ „
Depth in the hold	22 „ 3 „	21 „ 6 „
Proportion of breadth to length..	as 1:3.32	as 1:3.43
Burthen in tons	1709	$2046\frac{80}{94}$

The following Table, copied from Charnock, shows the dimensions proposed by the several master-shipwrights, in connection with those of the establishment of 1719.

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* Admiralty letter to Sir John Norris, admiral of the fleet.

† Charnock, Vol. III.

THE ROYAL GEORGE.

Built in the Reign of George II.

This Ship Sunk at Spithead on the 29th August 1782 having been inclined for the purpose of repairing a water-pipe passing through the Side below the water-line. Nearly 1200 persons were at that time on board, about nine hundred of whom were drowned.

PARTICULARS.		GUNS.																SLOOPS.	
		100.		90.		80.		70.		60.		50.		40.		20.			
		Feet.	Ins.	Feet.	Ins.	Feet.	Ins.	Feet.	Ins.	Feet.	Ins.	Feet.	Ins.	Feet.	Ins.	Feet.	Ins.	Feet.	Ins.
Length on the gun-deck from the rabbit of the stem to the rabbit of the post.	Per Establishment of 1719	174	0	164	0	158	0	151	0	144	0	134	0	124	0	106	0	——	
	Mr. Ward's proposition	174	0	169	0	161	0	154	0	144	5	134	9	125	2	106	0	——	
	Mr. Stacey's ,,	175	0	167	0	160	0	151	0	144	0	134	0	124	0	105	0	87	6
	Mr. Hayward's ,,	174	0	166	0	158	0	151	0	145	0	136	0	127	0	109	0	80	$0\frac{3}{16}$
	Mr. Allen's ,,	——		165	$9\frac{1}{4}$	158	0	152	0	143	0	135	0	127	$2\frac{3}{4}$	106	0	80	6
	Mr. Locke's ,,	——		——		160	0	151	0	144	0	135	9	127	6	109	0	——	
Breadth, extreme.	Per Establishment of 1719	50	0	47	2	44	6	41	6	39	0	36	0	33	2	28	0	——	
								44	10										
	Mr. Ward's proposition	50	0	48	2	46	1	42	6	39	8	37	1	34	6	29	2	——	
	Mr. Stacey's ,,	50	4	48	0	46	0	41	6	39	7	36	10	34	1	29	1	23	0
	Mr. Hayward's ,,	50	0	47	8	45	5	43	4	41	0	38	6	36	0	30	10	24	0
	Mr. Allen's ,,	51	0	48	7	46	$3\frac{3}{4}$	43	3	40	9	38	$4\frac{3}{4}$	36	1	30	6	24	6
	Mr. Locke's ,,	——		——		44	6	41	6	39	6	37	4	35	0	30	0	23	4
Depth in hold.	Per Establishment of 1719	20	0	18	10	18	2	17	4	16	5	15	2	14	0	9	2	——	
								18	4										
	Mr. Ward's proposition	20	0	19	2	18	5	17	0	15	10	14	9	13	9	11	7	——	
	Mr. Stacey's ,,	20	6	19	7	18	9	17	4	16	6	15	5	14	3	9	5	10	0
	Mr. Hayward's ,,	20	4	19	5	18	5	17	7	16	11	15	4	14	4	11	6	9	6
	Mr. Allen's ,,	20	0	19	$0\frac{1}{2}$	18	$1\frac{3}{4}$	17	$3\frac{3}{4}$	16	$7\frac{3}{4}$	15	$4\frac{1}{4}$	14	$5\frac{3}{4}$	9	$1\frac{3}{4}$	9	6
	Mr. Locke's ,,	——		——		18	6	17	4	16	5	15	2	14	0	9	2	9	6
		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.		Tons.	
Burthen in tons.[1]	Per Establishment of 1719	$1869\frac{43}{64}$		$1566\frac{52}{64}$		1350		$1128\frac{28}{64}$		$951\frac{47}{64}$		$755\frac{52}{64}$		$594\frac{44}{64}$		$374\frac{43}{64}$		——	
	Mr. Ward's proposition	1870		1680		1460		1240		1005		818		660		400		——	
	Mr. Stacey's ,,	1903		$1651\frac{38}{64}$		$1454\frac{44}{64}$		$1128\frac{42}{64}$		$977\frac{15}{64}$		$787\frac{14}{64}$		$624\frac{55}{64}$		$392\frac{51}{64}$		200	
		Feet.	Ins.	Feet.	Ins.	Feet.	Ins.	Feet.	Ins.	Feet.	Ins.	Feet.	Ins.	Feet.	Ins.	Feet.	Ins.	Feet.	Ins.
Draught of water.[2]	Per Establishment of 1719. afore	21	6	20	2	19	0	17	7	16	6	13	10	13	10	11	4	——	
	Per Establishment of 1719. abaft	22	10	21	6	20	4	18	11	17	10	12	[3] 10	14	10	12	4	——	
	Mr. Allen's proposition. afore	21	$4\frac{3}{4}$	20	4	19	$6\frac{1}{4}$	17	0	15	$11\frac{1}{2}$	14	$11\frac{3}{4}$	14	0	11	0	7	9
	Mr. Allen's proposition. abaft	22	$10\frac{3}{4}$	21	10	21	$0\frac{1}{4}$	19	0	17	$11\frac{1}{2}$	16	$11\frac{3}{4}$	16	0	12	$9\frac{3}{4}$	11	3

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[1] The burthen is not given to the proposed constructions of Messrs. Hayward, Allen, and Locke; — [2], Nor the draught of water to those of Messrs. Ward, Stacey, Hayward, and Locke.
[3], Apparently an error.

The *Blenheim* of ninety guns was constructed by Sir Thomas Slade, according to the dimensions which had been determined on in 1748, and was laid down at Woolwich in 1756, and launched five years afterwards. The *Princess Amelia* of eighty guns on three decks, was a very superior ship in her time; the high estimation in which she was held being attested by the frequency with which she was employed during the whole time she was fit for service. She was constructed according to the establishment of 1745; laid down at Woolwich in 1751, and launched in 1757.

The principal dimensions of these two ships were as follows:

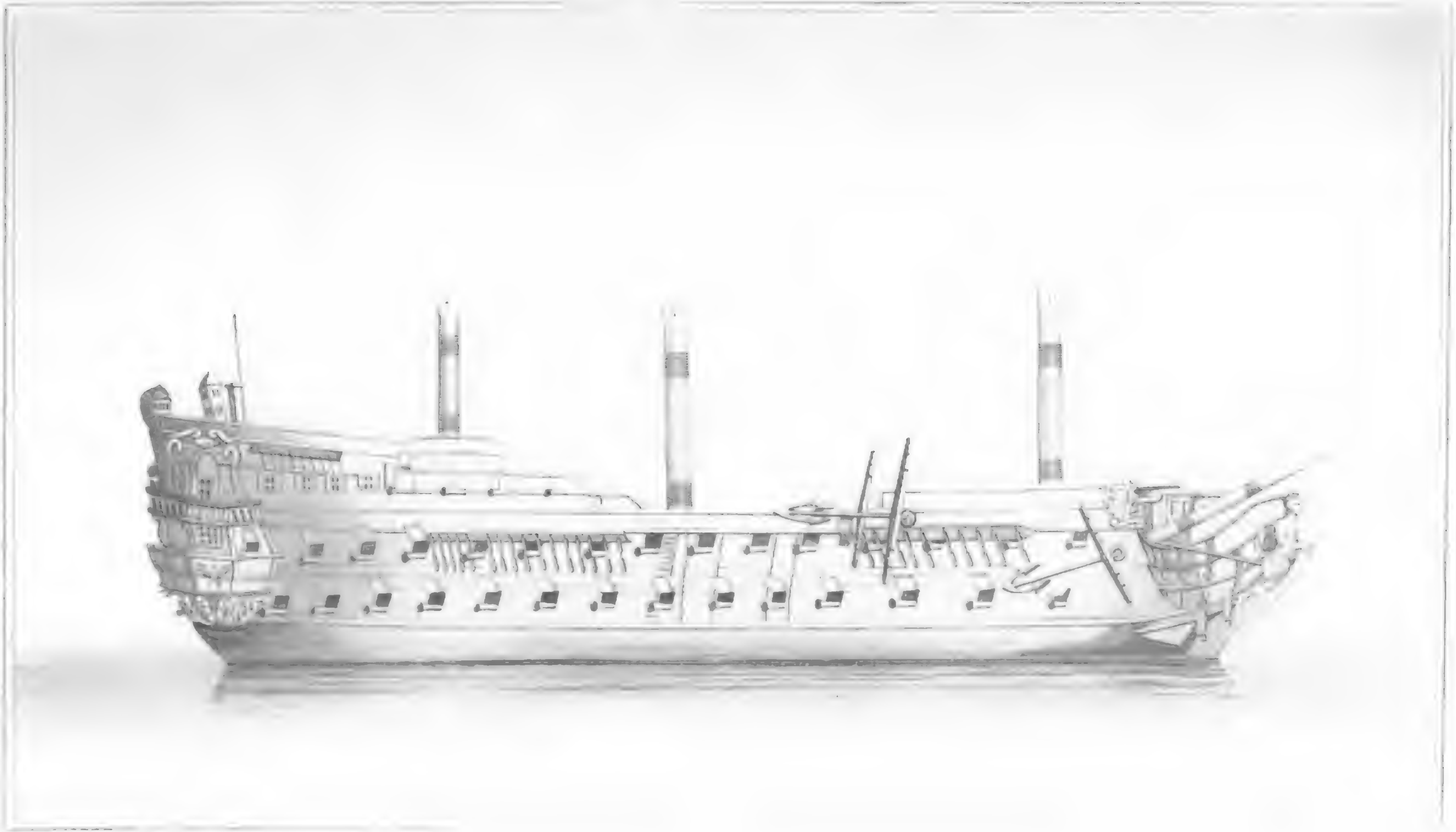
	Blenheim.	Princess Amelia.
Length on the gun-deck........	176 ft. 1 in.	165 ft. 0 in.
Length of the keel for tonnage..	142 „ 7 „	133 „ 0 „
Extreme breadth..............	49 „ 1 „	47 „ 3 „
Depth in the hold	21 „ 0 „	20 „ 0 „
Proportion of breadth to length..	as 1: 3. 58	as 1: 3. 49
Burthen in tons	1827	1579$\frac{19}{94}$

The capture of the *Invincible* of seventy-four guns from the French, in 1747, led to an increase of dimensions in British ships of the same force. This was deemed a very superior ship; and her dimensions, with a diminution of six inches in the extreme breadth, and four inches in the length of the keel, were taken in constructing the *Triumph*, a seventy-four gun ship, which was laid down at Woolwich in 1758, and launched in 1764. The *Mars, Thunderer*, and *Canada* were other ships of the same rate, and built about the same time. The following were their principal dimensions:

	Triumph.		Mars.		Thunderer.		Canada.	
	Feet.	in.	Feet.	in.	Feet.	in.	Feet.	in.
Length on the gun-deck . .	171	3	165	6	166	6	170	0
Length of the keel for tonnage .	138	8	134	4	136	0	130	1
Extreme breadth . . .	49	9	46	8	47	2	46	9
Depth in the hold . . .	21	3	19	9	19	9	20	6
Proportion of breadth to length	as 1:3.44		as 1:3.54		as 1:3.53		as 1:3.63	
Burthen in tons . . .	1825$\frac{53}{94}$		1556$\frac{19}{94}$		1609$\frac{33}{94}$		1606$\frac{34}{94}$	

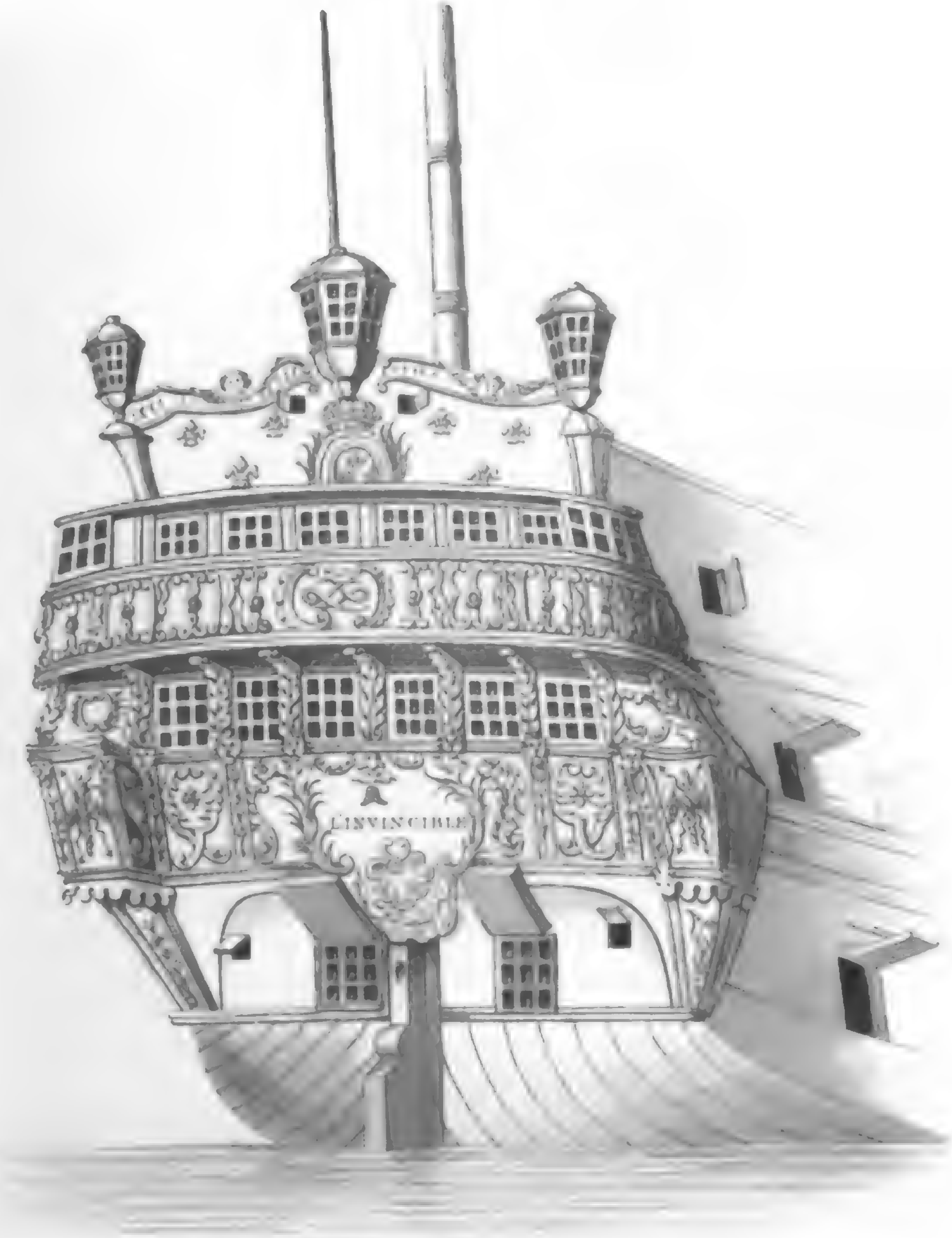
The results of observation and experience led to some alterations in the classes of ships inferior to those just mentioned: the building of seventy gun ships was discontinued; only five of them were launched in England after 1750; the *Boyne*, constructed by Sir John Allen, which was the last of this class of ships, was launched at Plymouth in 1766. Three ships of sixty-eight guns were launched in 1750 and 1758; and we find no more

THE INVINCIBLE, FRENCH 74 GUN SHIP, CAPTURED IN 1747.



HEAD OF THE INVINCIBLE.

STERN OF THE L'INVINCIBLE.



of that class built during the remainder of the century. Only one of sixty-six guns was built after the year 1739, and that was the *Lancaster*, launched at Woolwich in 1749.

Ships of sixty-four guns were of the smallest force that were now denominated "of the line;" and their dimensions were considerably enlarged. A comparison of two ships, one launched at Deptford in 1742, and the other constructed by Sir Thomas Slade, in 1764, will show the enlargement of dimensions by which ships of that class were improved.

Ships.	When launched.	Length.				Extreme Breadth.		Depth in Hold.		Burthen in Tons.	Proportion of Breadth to Length.
		On gun-deck.		Of keel.							
		Feet.	in.	Feet.	in.	Feet.	in.	Feet.	in.		As
Revenge .	1742	151	0	124	$6\frac{1}{8}$	43	7	17	9	1258	1:3.46
St. Albans	1764	159	$3\frac{3}{4}$	130	$9\frac{1}{2}$	44	$6\frac{1}{2}$	18	$9\frac{3}{4}$	1380	1:3.57

Ships of sixty guns were now removed from the line, although they appear to have been occasionally placed in the line of battle long after that period; but although no longer designed to occupy that position in general engagements, it was nevertheless deemed requisite, for the service in which they would be employed, that their dimensions also should be enlarged. The *Dreadnought* was launched in 1742; and the *Edgar* of the same class in 1758. The following were their principal dimensions:

	Dreadnought.	Edgar.
Length on the gun-deck........	144 ft. 1 in.	154 ft. 6 in.
Length of the keel for tonnage ..	118 „ 2 „	127 „ 0 „
Extreme breadth..............	41 „ $7\frac{1}{2}$ „	43 „ 10 „
Depth in the hold	16 „ 11 „	18 „ 3 „
Proportion of breadth to length..	as 1:3.46	as 1:3.52
Burthen in tons	1093	1297

Ships of fifty guns were next in the scale of the establishment at this time; but though they were nominally rated at fifty, they sometimes carried fifty-four, and occasionally fifty-eight guns. The *Romney*, constructed by Sir Thomas Slade, was considered a fine ship of this class, and was employed for nearly forty years in the service: she was laid down in 1759, and launched at Woolwich in 1762; her principal dimensions were as follows:

Length on the gun-deck............	146 ft. 0 in.
Length of the keel for tonnage	120 „ $8\frac{1}{3}$ „
Extreme breadth..................	40 „ $4\frac{1}{3}$ „
Depth in the hold	17 „ 2 „
Proportion of breadth to length......	as 1 : 3.61
Burthen in tons	$1046\frac{1}{94}$

The next inferior class of ships was that with forty-four guns on two decks, which Charnock says, were "the worst vessels which at that time composed any part of the British navy." The *Ludlow Castle* and the *Phœnix* may be mentioned as examples of this construction; the former was launched in 1744, and the latter in 1759. The following were their principal dimensions:

	Ludlow Castle.	Phœnix.
Length on the gun-deck........	126 ft. $10\frac{5}{8}$ in.	140 ft. 9 in.
Length of the keel for tonnage ..	103 „ 8 „	116 „ $10\frac{3}{4}$ „
Extreme breadth..............	36 „ 3 „	37 „ $1\frac{3}{8}$ „
Depth in the hold	15 „ $5\frac{1}{2}$ „	16 „ 0 „
Proportion of breadth to length..	as 1:3.5	as 1:3.69
Burthen in tons	725	856

There had been, until very recently, no class of vessels between this and the twenty-four gun frigates: the *Dolphin* may be taken as a specimen of these vessels; she was launched at Woolwich in 1751; and her principal dimensions were as follows:

Length on the gun-deck	113 feet 0 in.
Length of the keel for tonnage	93 „ 4 „
Extreme breadth	32 „ 1 „
Depth in the hold	11 „ 0 „
Proportion of breadth to length	as 1:3.52
Burthen in tons	511

About this time, however, ships mounting thirty-six, thirty-two, and twenty-eight guns, were brought into the service. In the years 1757 and 1758, three thirty-six-gun ships of Sir Thomas Slade's construction were launched; but, after these, there were no other ships of the same force built for a number of years. From 1757 to 1760, thirteen 32-gun ships were launched, almost all of which were of Sir Thomas Slade's construction; and the same class of vessels continued to be built. From 1756 to 1760 nineteen ships of twenty-eight guns were launched; and these also were of Sir Thomas Slade's construction. The principal dimensions of the *Pallas* of thirty-six, the *Stag* of thirty-two, and the *Argo* of twenty-eight guns, are given in the following table.

Ships.	When Launched.	Length.				Extreme Breadth.		Depth in Hold.		Burthen in Tons.	Proportion of Breadth to Length.
		On Gun-deck.		Of Keel.							
		Feet.	in.	Feet.	in.	Feet.	in.	Feet.	in.		As
Pallas. .	1757	128	4	106	4	35	$10\frac{3}{4}$	12	4	728	1:3.58
Stag . .	1758	125	$2\frac{1}{2}$	103	$8\frac{1}{2}$	35	$9\frac{1}{2}$	12	0	706	1:3.5
Argo . .	1758	118	$5\frac{3}{4}$	98	1	33	$11\frac{1}{8}$	10	6	601	1:3.69

All these ships were built in the river Thames.

The evils arising from the presence of bilge-water and foul air in the holds of ships continued without any adequate remedy till the year 1753, when Dr. S. Hales brought under the consideration of the lords commissioners of the admiralty a method of ventilation, which was calculated greatly to diminish them. Experience had demonstrated the fact, that the presence of these deleterious agencies affected both the ships and their crews; and the quantity of carbonic acid gas which is constantly produced in a large ship by several hundred men sleeping between the decks, exhausting the vital part of the air, and leaving a deleterious atmosphere in its place, to subside into the lower parts of the ship, and produce combinations of a destructive character, affecting both the ship and the health of all on board, was obviously of such importance as to claim the attention of those, whose acquaintance with the subjects under consideration, would fit them to devise proper means to counteract their natural tendencies.

The means which Dr. Hales recommended were, the employment of wind-mills and large air-pumps; and certainly, the principles on which he proceeded were correct, although, like most original contrivances, the arrangements for giving effect to his principles were cumbersome, and comparatively rude. The result of his endeavours was, however, highly beneficial. By the means he recommended, a current of pure air was produced in the hold, which put in motion the heavy part of the air which lodged there, and this was then drawn off, whilst a current of fresh atmospheric air was introduced to supply its place.

The beneficial effects of Dr. Hales's method of ventilation were rendered sufficiently obvious whilst it was in use, by the fact, that from 1753, when it was first employed in the old *Prince,* till about the year 1798, when the use of it was discontinued, the durableness of ships was materially improved; and the salutary effects of it upon the health of the crews of those ships to which it was applied (especially transport and store-ships), was attested by the earl of Halifax, who, in a letter to Dr. Hales, stated that the mortality in the ships on the coast of Nova Scotia, which were not ventilated, was, in comparison of those ships which were ventilated, as twelve to one.

Since the principles on which Dr. Hales proceeded in the ventilation of ships were true, the improvements which have been subsequently made have consisted rather in simplifying the means of carrying them into effect, than in any originality of conception. But the object which is aimed at, whether by Dr. Hales's wind-mills and air-pumps, by Mr. Parkins's ventilators, by fans, or by heat, has not yet been fully realized; that of producing a constant disturbing force in the lower part of the hold, which should give motion to the foul air that would have a natural tendency to lodge there, whilst suitable means were at the same time in operation for conveying away this foul air, and supplying its place by the introduction of pure atmospheric air. The constant operation of some means to produce this effect is necessary to the preservation of the timbers of ships, of the stores they have on board, and of the health of the crew. The three objects contemplated in effective ventilation bear a necessary relation to each other; and it is obvious that simplicity is most desirable in any plan for ventilating ships.

The introduction of dry and pure air into the hold is requisite to carry off the humid particles which adhere to the interior of a ship, and excite the latent elements of decay which, under circumstances favourable to their development, are soon apparent. But if the openings in the frame of a ship were made to form air-tubes for this purpose, which might be done at a small expense, if the arrangement were carried on simultaneously with the building of the ship, there would be a permanent means of ventilating every part of the structure; and air-pumps may be made to act in connection therewith. And in the absence of air-pumps, the common pumps of the ship may then be made to answer the purpose, by first pumping the well dry, and then continuing to work the pumps; for when there is no longer any water to be brought up, the pumps will bring up the foul air, which, by its greater specific gravity will lie in the lowest parts of the hold; and the limber passage will be sufficient for drawing it from the parts of the hold in which it may have collected. A method of ventilation identified with the construction of the ship, and of easy operation, would obviously prove to be of more general application and efficiency than an arrangement of apparatus of a cumbrous description, however ingenious the contrivance of it may be.

In the same year, the quarter-deck in small frigates was carried forward to the main-mast; previously to this time it was short, and the deficiency of length was supplied by gangboards in the waist, which rested on iron knees. And in 1754, the rudder heads in ships of fifty guns and upwards were lengthened: instead of being so long as to admit only one tiller to be shipped below the upper deck, the rudder heads were carried up, so that in the event of the lower tiller being carried away, another might be shipped above the upper deck to supply its place.

In March, of the year 1755, it was announced in the House of Commons, that a war was likely to take place between this country and France; this apprehension was excited by the hostile preparations which France had been for some time past making in North America; and the house granted the sum of one million sterling for the defence of the British North American colonial possessions. Squadrons were fitted out, and hostilities were begun by attacking and capturing two ships of a squadron sent from France to North America. About three hundred French merchantmen were captured likewise during the year; but no declaration of war had been issued. This formality did not take place till June, 1756.

Great alarm was expressed at the prospect of an invasion of either England or Ireland; but it is doubtful whether this was the object of the French in any of the preparations they were making. Repeated intimations were given to the British government, in the early part of 1756, of the fitting out of a fleet at Toulon, and that Minorca was supposed to be the point of destination of this fleet. After considerable delay, admiral Byng was sent out with a fleet inferior to that of the enemy, and also indifferently manned; it consisted of ten ships of war, without either hospital or fire-ship, although there were at that time more than one hundred and fifty ships of war in commission; and it was known to all Europe* that the French squadron at Toulon consisted of thirteen ships of the line. On the 20th of May an engagement took place between the two fleets off Minorca, and the result was, that the English failed of obtaining a victory; and admiral the Honourable John Byng was shot at Portsmouth in 1757, for not doing his utmost towards taking or destroying the French fleet, after a trial by court martial.

But little further of importance was accomplished during the remainder of the year, or in fact during the following year, in Europe. In the East Indies, however, the squadrons were more vigorously and successfully employed. The English had been defeated at Calcutta, and that city had fallen into the hands of the native Indians. Admiral Watson determined on attempting to recover that place; and the small squadron under his command was directed to that service, which, in connection with a military force, under colonel Clive, was very successfully performed in the beginning of January, 1757.

In 1758, sixty thousand seamen and marines were voted for the service of the navy, which, at that time, consisted of one hundred and fifty-six ships of the line, and one hundred and sixty-four ships of war of inferior rates. There were then also on the stocks four ships of 74 guns, two of 70, four of 64, six of 36, and ten of 28.

The employment of the fleet became more vigorous after the administration of the government came into the hands of Mr. Pitt. In America the English were superior at sea to the French, and aimed at recovering Louisbourg, which had recently been overcome by the enemy. In Europe the fleets of Great Britain were employed to prevent the sending out of a reinforcement, by keeping a vigilant guard off the ports in which fleets and squadrons were lying; and in the Mediterranean, the project of sending out assistance was necessarily abandoned, in consequence of the defeat of the Toulon squadron by that under admiral Osborne, on the 27th of April. Nor did the preparations, which the French were making in the ports of the Bay of Biscay, escape the vigilance or the interference of the English; several ships were taken, others were driven on shore, and a few succeeded in crossing the Atlantic.

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* Campbell, Vol. V., p. 2.

During the summer, the fleets were diligently employed against the coasts of France; and troops were landed, and having marched to St. Malo, they destroyed about 120 ships and vessels which were lying in the harbour, and set fire to a number of magazines and storehouses. They also invaded, and took the town of Cherbourg. Here they destroyed a small number of ships and vessels in the harbour, and also the fortifications, the basin, and other works by which the harbour was in the course of improvement for the accommodation of the French navy. A landing of troops was again effected in the month of September, and they destroyed a few vessels lying in the harbour of St. Brieux; but in a march of some distance, to be re-embarked, the English were overtaken by a French army, and lost about seven hundred out of their fourteen hundred troops.

The recovery of Louisbourg was the result, principally, of military operations, since the French had used the best precautions they were able, to keep the English ships out of the harbour, in which several of their ships were lying. Four ships of the line were burnt, and one was brought off, as were also two frigates.

In the year 1759, the English fleet in the West Indies was employed against such of the French colonies as it was thought desirable and practicable to get possession of, and not without some success. But the grand object towards which the services of both army and navy were directed, was the conquest of Canada. In this enterprise, the fleet rendered all the assistance in its power, whilst the taking of Quebec was principally a military achievement.

A fleet from Toulon was defeated by Admiral Boscawen; but still there was at Brest a considerable fleet, and another at Dunkirk. These were blockaded by English fleets; but the latter put to sea, eluded the English fleet, and took refuge in a port of Sweden. The former also put to sea, and was brought to an engagement by the fleet, under the command of Admiral Hawke, who obtained an important victory, by sinking, capturing, or driving on shore several of the enemy's ships, whilst his own fleet suffered the loss of two ships which ran upon a sand-bank, and were lost. This defeat deprived the French of the last vestige of hope of being able to carry on successfully a maritime war with England; and, according to Voltaire, the English had never before attained to so decided a superiority at sea, as that by which they were now distinguished. This relatively high position of the British navy was not permitted to lead to any relaxation of those efforts by which this eminence had been reached. The number of seamen and marines voted for the public service in 1760, was seventy-three thousand; and the sum of three millions six hundred and forty thousand pounds, was granted for their maintenance.

At the commencement of this year, the navy consisted of a hundred and twenty ships of the line, besides frigates, fire-ships and other smaller vessels; and these were dispersed in strong forces over the different quarters of the world, where they were employed in the services which became necessary, and with especial success in North America, where the appearance of a squadron compelled the French to raise the seige of Quebec; the consequence of which was, that the whole of Canada came into the possession of the English. This was the most important acquisition made during the war.

The French navy had become so weakened, that few ships were left to be employed; and consequently, no more than six ships of war were taken by the English during the year; whilst more than a hundred privateers, and armed merchantmen were captured. In the same year, the English lost two ships of the line,—the *Conqueror* of sixty-eight guns, only two years old, off the coast of Devonshire; and the *Ramillies* of ninety guns, was driven upon the rocks at Plymouth, and wrecked.

In the midst of the successful prosecution of the war in all parts of the world, the king died suddenly at his palace, at Kensington, on the 25th of October, 1760. He was succeeded by his grandson George the third, the eldest son of Frederick Lewis, prince of Wales, who had died in 1751.

The accession of George the third was not followed by any immediate consequences, in prosecuting the war; but the same vigorous measures were carried on in 1761. The channel fleet was employed in an expedition against Belle Isle, when that island was reduced. In the East Indies, Pondicherry was taken by the fleet, under the command of admiral Stevens, after a very obstinate resistance. And, in the West Indies, the island of Dominica was taken from the French, whose possession of it was deemed a violation of the neutrality.

The continual triumphs of the English, led to proposals from France for a cessation of hostilities; and negotiations were commenced in London, for the restoration of peace, and were carried on for some time, until the interference of Spain interrupted them, and indicated the prospect of a war with that country. This occurred only in the following year, after negotiation to avoid it had been tried without effect.

When the war with Spain broke out, in January, 1762, the navy of that country consisted of eighty-nine sail, besides bomb-ketches and fire-ships. These, when brought into combination with the remnant of the French navy, presented a formidable array of hostile power on the sea; but by no means such as to intimidate Great Britain.

The English renewed the vigour of their exertions in carrying on the war in 1762; the naval operations began in the West Indies, in the reduction of Martinique and other of the Carribee Islands, by a fleet under the command of rear-admiral Rodney, in connection with land forces. Early in March, another fleet sailed from England, under the command of admiral Pocock, the object of which was to make an attack upon the Havannah. This, being the centre of Spanish commerce in the West Indies, was very strongly fortified. The fleet appointed to serve against this place, was re-inforced by a part of rear-admiral Rodney's fleet, and now amounted to nineteen sail of the line, eighteen smaller vessels of war, and about one hundred and fifty transports. The expedition fully accomplished the service on which it was sent: the English gained possession, after a siege of forty days, of one of the principal forts; and from that time, their operations were directed against the city, the governor of which was at length obliged to capitulate, surrendering the city, harbour, and twelve ships of the line which were lying there, to the victorious English.

The fleet in the Mediterranean was suitably re-inforced, that it might be able to face the French and Spanish fleets, either separately or in combination. A fleet was sent out to the succour of Portugal, when that country was menaced with the vengeance of France and Spain, for not uniting in their interests in the war. The reduction of the Phillipine Islands was the achievment of a small expedition, fitted out in the East Indies, conducted by colonel Sir William Draper and admiral Cornish; but in the siege by which the possession of Manilla was obtained, the service which the fleet performed was necessarily, from the circumstances of the case, very subordinate. St. John's, in Newfoundland, was recovered by a small force provided in North America; this armament was fitted out without any instructions being sent from England for that purpose; and the service was performed, whilst preparations were being made in England for the same object.

Besides the expeditions which were undertaken for specific purposes, the English had fleets, squadrons, and single cruisers, wherever their services were supposed to be capable of promoting the British naval ascendency. These fleets, squadrons, and cruisers, on their respective stations in different parts of the world, amounted to more than two hundred and forty ships of war; and the services performed by them, were of the most important character in the prosecution of the war: they captured eighteen ships of the line, and twice that number of frigates from the French, who had likewise fourteen ships of the line, and thirteen frigates destroyed. The loss of the Spanish amounted to twelve ships of the line, besides frigates, while the English cruisers took also a considerable number of smaller ships from both the French and Spaniards; but their own losses were at the same time considerable; thirteen ships of the line, and fourteen frigates were lost by accident, three frigates were destroyed, and two captured by the French. But little more was performed by the navy during the war, which was now fast drawing to a close, and was followed by the treaty of Paris, in February, 1763, by which France ceded Canada, and Spain, Florida, to Great Britain.

From this time, the principal service of British cruisers was that of having a vigilant regard to the occurrences in the West Indies, and on the coast of America, with a view to compel the performance of the conditions on which the peace had been established; and likewise to enforce the observance of certain regulations relating to the commerce carried on between the North American colonies, and the West India Islands. This latter service, performed with excessive rigour, was one of the causes of the discontent which led to the unhappy war between Great Britain and her colonies.

It was in consequence of the rapid decay of the ships of the royal navy during the war, that in the year 1771, great attention was paid to the seasoning of timber used in ship-building; and particular instructions were given, with a view to ensure greater durability. It was directed that larger stocks of timber should be laid up in each of his majesty's dock-yards; that the building slips in each yard should have ships set up on them; that line-of-battle ships should stand in frame to season, at least one year, before the thick-stuff and plank were brought on; that frigates should stand at least six months; that all thick-stuff and plank should be sawn out at least one year before it was used, and stacked with battens placed between the planks, for the air to circulate freely between them; that the beam pieces should be cut out, and be stowed on end, round the brows and standards of the slips; and not be used till they should have stood six months; and that all knees should be sided as soon as received into the yards, and kept side by side under dry sheds, with battens between them. It was likewise ordered that, owing to the scarcity of large timber, some ships of the line should be repaired with foreign oak; and in order to obtain greater durability, it was also directed that no plank should be boiled, except for the bows and buttocks of ships; and that salt-water only should be used: and in 1788, with the like object in view, it was directed that though the frames had stood to season the prescribed period, the ships nevertheless were not to be proceeded with, until the whole of the thick-stuff, plank, beams, knees, &c., had been seasoned for at least six months.

Most of the classes of new ships, from forty-four guns and under, had had their dimensions increased during the war; and most of the second rates of ninety guns, were established with eight additional guns for their quarter-decks, which made them ninety-eight-gun ships. The ninety-eight-gun ships, as the *Barfleur, Duke, Prince George, St. George, Queen, Princess Royal,* &c., built between 1756 and 1788, were in length on the gun-deck 177 feet 6 inches, and in extreme breadth from 49 feet 6 inches to 50 feet 6 inches. The ninety-eight gun ships that followed these, launched between 1794 and 1798, as the *Dreadnought, Neptune, Temeraire,* and *Prince of Wales,* had their lengths of gun-deck from 182 to 185 feet, and their extreme breadth from 50 feet 6 inches to 51 feet 2 inches. The *Prince,* of ninety-eight guns, built in 1788, was lengthened at Portsmouth, in the year 1796, to 194 feet 6 inches, about seventeen feet; and the *Ocean*, launched at Woolwich, in 1805, had been lengthened on the stocks to 196 feet 6 inches. The *Queen*, *Blenheim*, and *Namur*, were reduced to two-deck ships.

The period of peace was distinguished by voyages of discovery towards the antarctic pole, with the hope of discovering a continent which was supposed to exist there, and for the discovery of lands in the South Seas; or, as it was expressed in the instructions given to commodore Byron, who commanded the first expedition, "there is reason to believe that lands and islands of great extent, hitherto unvisited by any European power, may be found in the Atlantic Ocean, between the Cape of Good Hope and the Magellanic Straits, within the latitude convenient for navigation, and in climates adapted to the produce of commodities useful in commerce." Another voyage was performed by captains Wallis and Carteret.

From objects which were purely geographical, discoveries of a more highly scientific character proceeded, and became associated with maritime enterprise; and at length a voyage was undertaken into the Pacific Ocean, for the purpose of improving the principles of navigation, by observing the transit of the planet Venus across the disc of the sun. Repeated expeditions were conducted into the Pacific by the same eminent officer, captain Cook; and the spirit of nautical enterprise received from these efforts an impulse which has never been lost. A detail of these enterprises cannot be given here; but the results of them have been long since made known by the works written expressly on those subjects.

The importance of preserving ships' bottoms from the injuries to which they are constantly exposed by marine animals, and the loss of speed to which the accumulation of marine vegetables subjects them, has at different times drawn particular attention to this subject: and various attempts have likewise been made to prevent injury to the bottoms of ships from the different species of worms. Experiments have been made at different times to protect them by means of lead sheathing; especially in the reign of Charles the Second, when the experiment was made to a considerable extent: as we find that, in the year 1670, an act of parliament was passed, granting to Sir Philip Howard and Francis Watson, Esq., the exclusive privilege of manufacturing milled lead for this purpose; and from that time, to this year, 1691, twenty ships were sheathed with lead of their manufacture, fastened to the bottoms of the ships with copper nails.

Although the use of wood sheathing prevailed generally, till a period somewhat later than the middle of the last century, yet lead sheathing was not wholly discontinued in the British navy, till a few years after the introduction of copper sheathing for the same purpose; for both the *Marlborough* and the *Egmont* were afterwards sheathed with lead. But after those ships had been to sea, it was finally determined that the metal was not hard enough to endure long the action of the water. In the beginning of the year 1770, when the *Marlborough* was examined, at Sheerness and Chatham, the whole of the sheathing was off, except a small portion upon the knee of the head, and on the rudder: the bottom of this ship was then covered with wood sheathing.

In connection with the sheathing of wood, several means were used to increase the efficiency of that mode of protection: and although some of them were highly useful in resisting the action of the worms, yet they had no tendency to check the adhesion and growth of sea-weeds. Among them may be mentioned the graving of the bottoms, or the paying of them over with a composition prepared for that purpose; and the filling of the sheathing with nails, called filling nails, having large heads, so thickly driven, as to form almost an entire sheathing additional to the wood. Several sorts of graving were used upon the bottoms of ships; one of these, which was a composition prepared by Mr. Lee, the master caulker of Portsmouth dockyard, was found very efficacious in resisting the action of the sea-worm. It was made of pitch, tar, and brimstone. This composition was tried at Portsmouth in 1737, in comparison with the white and black gravings, and other preparations made by colonel Gashry, captain Jacob Rowe, and Mr. Hammond: and it was found that after two years, the worm had not penetrated Mr. Lee's composition, whilst the others were in various degrees destroyed. After this experiment had been made, Mr. Lee's composition was generally used for graving.

But none of these means were calculated to prevent the ships from becoming foul by the adhesion and growth of barnacles and marine vegetables. It was therefore highly important that something better suited to this purpose should be tried, that should be sufficient for the preservation of the ships' bottoms, both from injury to the plank, and obstruction to their sailing.

Complaints were, however, still made, that the worm continued to make very destructive ravages upon the bottoms of ships, especially those employed in the West Indies. This fact was represented to the admiralty in a letter from the navy board, dated the 18th of October, 1761: and in the same letter it was proposed to make an experiment for the preservation of frigates, to be employed in the West Indies, by sheathing them with "thin plates of copper." The lords of the admiralty therefore, in their letter of the 21st of the same month, directed the navy board to cause the bottom of the *Alarm* thirty-two-gun frigate, to be sheathed with copper, by way of experiment. This frigate was fitted out for the West India station; and after a sufficient time had elapsed for the result of the experiment to be determined with certainty, the ship was examined, and the sheathing was found to have answered very well, both in preserving the bottom from injury by the worm, and in keeping it comparatively free from the adhesion and growth of marine vegetables and barnacles. But after the sheathing had remained on several years, it was discovered that through the connection of the copper sheathing with the iron bolts in the bottom, and with the pintles for the rudder, these were so extensively oxidized as to be in a great measure destroyed.

The use of copper sheathing was subjected to further experiments upon the *Aurora* and *Stag*, to which it was applied in the summer of 1769. The *Aurora* was the second ship that was sheathed with copper; and particular instructions were given for performing this work. The bottom was to be breamed, that it might be quite clean to receive the sheets of copper; and such expedients were ordered to be used as were supposed to be capable of preventing the mischief which had been produced by the copper sheathing on the *Alarm*. The means which were used on the *Aurora* to prevent oxidation were, the paying over all the ends of bolts and other iron-work in the bottom, with *soft stuff*,* and covering them with canvas, and then covering these places with a piece of very thin sheet lead. For the protection of the pintles of the rudder, the sides and back of the stern-post, and the beardings of the rudder, were to be covered with sheet lead; and the sides of the rudder with the thinnest sheet lead that was used in the dock-yard.

After the copper had been on nearly four years, the *Stag* was examined very carefully, and the copper was found to be still an entire sheathing, although it had become thin at several parts, and at some places it was drawn a little from the planks. On examining more thoroughly the state of this ship's bottom, it was found that the bolts were very much oxidized; those which passed through the side were corroded to the inside of the timbers; but beyond this, the corrosion was not found to extend.

The use of copper in the navy went on with rapid increase; and in the course of a few years a very large proportion of the British navy was sheathed with that metal. But as this sheathing became general, and the effects of it became carefully investigated, it was discovered that the extent of oxidation of the iron bolts in ships' bottoms was so great, and its progress so rapid, that within a period of three or four years, the fastenings were injured so much, as to render the ships unfit to be sent on foreign service. The intervention of different substances, to prevent the contact of the two metals, had failed entirely of protecting the iron.

The injury to the fastenings of ships' bottoms became of so much importance, that, about the year 1783, the navy board appear to have seriously contemplated the discontinuance of copper sheathing to all ships lying in ordinary, and to have it applied to ships immediately before they were sent to sea. But in a letter, requiring the opinion of the master-shipwrights and other professional officers of the dockyards, the use of mixed metal bolts as fastenings for the lower part of ships was suggested. The suggestion was approved of, and the use of mixed metal bolts was recommended by them, as a means of obviating any inconvenience from ships lying in ordinary with copper sheathing upon their bottoms: and in August 1783, it was directed that mixed metal should be used in forty-four-gun ships and smaller vessels; and again, in October of the same year, copper bolts were ordered to be used in all classes of ships. The estimate, at that time, of the increased expense, through substituting copper for iron fastenings, was, for a first rate, £ 2272;— for a

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* A mixture of pitch and tar.

2nd rate,	90 guns,	£ 2018	5th rate,	32 guns,	£ 476
3rd ..	74 ..	1559	6th ..	28 ..	390
.. ..	64 ..	1178	.. ..	24 ..	337
4th ..	50 ..	872		20 ..	279
5th ..	44 ..	618		Sloop ..	210
.. ..	36 ..	528		Brig ..	158

At this period, physical science was not so far advanced, nor so generally understood, as to enable the officers, to whom this subject was referred, to investigate the causes of oxidation with reference to the elementary principles on which it is dependent; yet the general conclusion, to which their observation led them, was correct; that less oxidizable metal, used as fastenings of ships, would remain good, notwithstanding the copper sheathing. But the practical results which had come under their notice did not lead them to the conclusion which has since been well established; that two metals of different oxidizable tendencies, placed in connection by means of a corrosive fluid, will produce oxidation in that which is the more susceptible of it, unless the action be neutralized by some other means; and hence, that if the copper sheathing were more oxidizable than another metal with which it might be connected in the bottoms of ships, the sheathing would be the first to yield to the corrosive action that would be excited.

The corrosive action was, however, in some degree reciprocal, as the copper was also subject to a material loss, differing according to circumstances, some of which have been so abstruse as to elude discovery, under the most careful investigations that have been been pursued. The waste in the sheets of copper, rendering this means of preserving ships very expensive, has always been much felt. But the constant waste went on, and no means were used for arresting its progress; for the subject was not investigated in the light of modern science until the year 1823.

At that time the government requested the advice of the president and members of the Royal Society, as to the best method of manufacturing copper for the sheathing of ships, or of preserving it from corrosion upon their bottoms. Sir Humphrey Davy undertook the investigation of this subject, and the results of it were communicated to the Royal Society as they were developed.

The results of the series of experiments which the nature of his inquiry rendered it necessary he should make, led him to the conclusion that electro-chemical action was the chief cause of destruction to the copper sheathing of ships; and hence the means of diverting that action from the copper became the direct object of inquiry. The idea of the electrical states of several other metals in relation to that of copper, presented itself to him; and he discovered that if copper were rendered electro-positive by the contact of some metal more easily oxidizable than itself, as zinc or iron, that metal would divert the action from the copper, and preserve it from corrosion. It then remained only to apply this principle to the subject of inquiry. The selection of the most suitable metal for the purpose, the relative proportions of its contact with the sheathing, and the form in which it should be applied in that contact, were points to be determined.

As to the adaptation of material for protection, it was ascertained in the course of the experiments that cast-iron most effectually preserved copper from destruction in sea-water. The proportion of the copper which should be in contact with the protector, might vary between $\frac{1}{70}$th and $\frac{1}{110}$th of its surface; and an order of the 7th of June, 1824, directed, that the surface of the protectors in contact, should be $\frac{1}{80}$th of the surface of the copper. The form in which the protectors were applied was in bars, "six inches wide at their base, three inches in thickness at their centre, and in outward form, the segment of an extended circle," placed horizontally in midships about three feet below the surface of the water. On the keel they were "in a line with these," and they were continued as far towards the extremities of the ship as the form of the bow and stern would admit of the bars lying flat upon the surface of the copper. In putting the copper on the bottoms of ships fitted with these protectors, greater care was to be taken, to obtain the certainty of contact of the edges of the copper sheets, which was requisite to the perfect transmission of the voltaic action. A subsequent order, however, for applying the protectors to ships, states that Sir H. Davy had found the proportion of the cast-iron to be too great; and it was therefore ordered that only $\frac{1}{150}$th of the surface of the copper should be in contact with the protectors; and that the form of these should be altered, so that whilst the base should be still six inches in breadth, the greatest thickness should not be more than two inches, being still the segment of a circle; and orders were given, that all ships taken into dock should have these protectors applied to them.

As far as the protection of the copper was contemplated, the expectations of the inventor were fully realized. For when the copper on these ships was subsequently taken off and the sheets weighed, they were found to have been subject to "little or no loss"—proving that galvanic action was the principal cause of the destruction of copper on ships' bottoms, and the truth of the principle on which the means of protection had been selected and applied. But there was soon discovered an inconvenience incident to the use of these protectors, unforeseen in its character, and most material in its consequences. The ships became dull sailers; and on examination, it was found, that this was caused by a vast accumulation of shell-fish, marine insects, and vegetables all over the bottom. As no means were known to prevent such an effect, in connection with this method of preserving the copper, the use of these protectors was ordered to be discontinued on all ships in commission; but to be continued on ships lying in ordinary; but when the sheathing of these ships was examined, it was found to be in a worse condition than that on the ships which had been at sea; and the shell-fish adhered so firmly, that the copper was injured in separating them from it. Hence, the protectors were ordered to be discontinued altogether, with respect to all his majesty's ships, as well those lying in harbour, as those employed in sea-service.

Many cases having come under the immediate notice of the author, of ships both from foreign stations and in different circumstances in our own harbours, upon which the copper had sustained great loss; and various experiments having been made on copper taken from such ships to determine, by analysis, its quality; and the different portions of copper being found to be equally pure, it appeared to him, that the cause of greater wear in some cases in comparison with others was friction, rather than any chemical action; the effect of which might be limited by circumstances, so as to destroy one part of a ship's copper more than another part. He had been led to this conclusion, by observing, that the more prominent parts of the copper were the most acted on; but, upon examining, sometime ago, the copper taken from the bottom of a ship which had been on a foreign station, there were found under some of the barnacles which adhered to it, large deposits of muriate of lime; and where these deposits were found, the copper had been corroded through. Hence, he considers, that the chief cause of the rapid destruction of copper in those seas where coralline substances abound, and where there is probably the greatest quantity of the muriate of lime, is the same as that which was detected upon the ship mentioned.

Hitherto, the investigations of our most eminent chemists, have failed in accounting for the rapid wear of copper in many cases. The principal cause of the rapid corrosion of copper has, it is thought, been generally overlooked, viz., the want of due attention in the smelting and refining processes; so that the various foreign substances that are combined with the ore, such as antimony, sulphur, iron, &c., are not entirely extracted from the metal. Were the operation of refining more completely performed, old copper might be rendered preferable to new, by proper attention during the process and care in polling, as at each time of being melted, it undergoes, with this care, an additional refining process. But the various effects of the different degrees of hardness in the metal, may yet be referred to, for elucidating some of the difficulties of this subject; and the ores from which the metal is reduced, may become the subject of careful and successful investigation. It is well known to some, whose attention has been closely directed to this subject, that the hard and cold-rolled copper is more durable, and is kept clean longer, in consequence of its being brought into a more uniform degree of hardness, and therefore into a more equally oxidizable state; in which, consequently, it is less liable in itself to galvanic action.

The American war broke out in 1774. For a considerable time the means of that country seemed little calculated to carry on, successfully, a contest with so powerful a nation as England. Its resources for successful resistance to the government of the mother country, however, were gradually developed; and the English, who appear to have formed at first too low an estimate of the power of the Americans, at length found that they were engaged with a most formidable antagonist. "The whole of its state marine," says Charnock, "even after the war had continued for a considerable space of time, amounted to no more than ten or twelve frigates, including some vessels, which were scarcely entitled to so high a rank." But the American frigates were excellent vessels in point of sailing; and so, peculiarly adapted to the existing circumstances of the country at that time.

When the British government entered more vigorously into the prosecution of the war, a large number of cruisers was stationed on the coast of North America; but the course of the war was not much diversified by the services they performed, nor was it possible that it could become a naval war. The British fleet was chiefly auxiliary to the army; and in that subordination, and occasionally in distinct service, it served until the close of the war, when the independence of America was acknowledged, in 1782.

But before this event occurred, the convention between the king of France and the people of North America, in 1778, and the formal announcement of that convention by the Marquis de Noailles, led immediately to a war with France: and very active measures were forthwith put into operation to prosecute the war with vigour. The navy was said to be rendered available with great dispatch, by the fitting out of great numbers of ships; for the statements made by government, informed the nation that there was soon in commission a very formidable force, consisting of

1	ship of	100	guns.	6	frigates of	44	guns.
10	„	90	„	3	„	36	„
2	„	80	„	28	„	32	„
32	„	74	„	25	„	28	„
1	„	70	„	26	„	24 or 20	„
22	„	64	„				
4	„	60	„	55	sloops.		
13	„	50	„	——	Total	. 228	sail.

Very little important service was, however, performed by the fleets during the year. A general engagement took place on the 27th of July between the channel fleet, under admiral Keppel, and the French fleet, which had been fitted out at Brest; it lasted three hours, and they separated without any apparent advantage having been gained on either side; whilst the victory, gained by neither, was claimed by both.

In 1779 England suffered the loss of the islands of St. Vincent and Granada by the French fleet, in the West Indies, whilst the admiral who commanded it cautiously avoided a general engagement with the English.

Spain became confederate with France in the war in 1780, having put her navy into a condition suited to the services such an event would require. The fleets of France and Spain were brought together; and, entering the channel, where they remained several days without a fleet to engage them, threw the country into a violent alarm, as an invasion was apprehended. Nothing, however, appears to have been attempted; and when the English fleet returned to the channel, although it amounted to only thirty-nine sail of the line, besides frigates, whilst the combined fleet consisted of sixty-four ships of the line, four of 60, and one of 54 guns, besides a considerable number of frigates and smaller vessels, no very great effort appears to have been made to bring on an engagement. Nothing else on a large scale was attempted during the year.

Gibraltar was now enduring a severe siege; and in the beginning of 1781, Sir George Rodney, whilst conveying relief to the garrison there, fell in with a Spanish squadron, which he chased. In the engagement off Cape Saint Vincent, four ships of the line were taken,—two others, which had struck, were driven ashore, and one 70 gun ship blew up; whilst only four line of battle ships, and the two frigates in their company escaped. Admiral Rodney proceeded to take his station in the West Indies after he had conducted his charge safely to Gibraltar: and having arrived there, he exercised a very active command; but without being able to gain any important advantage over the French fleet, the admiral of which was unwilling to hazard the consequences of a general engagement.

The recovery of Gibraltar was a principal object aimed at by Spain, in the part that country took in the war. There was now little prospect of accomplishing this, unless relief could be excluded from the garrison, which by the end of 1780, was reduced almost to an extremity. The first employment of the navy in Europe, in 1781, was therefore to send relief, under the convoy of the best fleet that could be fitted out for that service; this it successfully performed, although there were lying, both at Brest and Cadiz, fleets whose object was known to be to prevent the accomplishment of such a service.

The fleet under the command of admiral Rodney, in the West Indies, having been unsuccessful in its endeavours to bring the French fleet under the command of admiral the Count de Grasse to a general engagement, sailed at length to the coast of North America, to render assistance to the colonies. A re-inforcement was then sent by Sir George Rodney to the fleet occupying the West India station; and a general action took place between the two fleets;' but it ended indecisively.

Instructions having been sent out to admiral Rodney, for the fleet under his command to be employed against the Dutch settlements in the West Indies, St. Eustatia, and other islands were taken by the English. They were now, therefore, engaged in hostilities with a people who had formerly proved themselves to be the most formidable enemies Britain had upon the ocean; and their character was soon found not to have been lost.

The war was distinguished, in 1782, by the great victory gained in the West Indies by Sir George Rodney over the French fleet, commanded by the Count de Grasse, who sustained a complete defeat, and was himself taken prisoner: and the naval performances in the East Indies, of the English fleet against the French, were distinguished for the great skill and bravery displayed on both sides; such that neither admiral could, in four general actions, gain an advantage over the other.

At the end of the year 1782, the number of ships and vessels in commission in the British navy, was only three less than the amount of the navies of France, Spain, and Holland. The following list from "Campbell's Lives of the Admirals," will show the naval power each of these nations had in its service at this period.

DESCRIPTION OF VESSELS.	Great Britain.	France.	Spain.	Holland.
Ships of the line	105	89	53	32
Fifty-gun Ships	13	7	3	0
Large Frigates	63	49	12	28
Small ditto	69	54	36	
Sloops	217	86	31	13
Cutters	43	22	0	0
Armed Ships	24	0	0	0
Bombs	7	5	14	0
Fire-ships	9	7	11	6
Yachts	5	0	0	0
Total	555	319	160	79

There were few naval events of much interest in 1783; a year which opened with the prospect of peace, and which witnessed the restoration of it amongst all the powers that had been engaged in the war with Great Britain.

During the early part of the American war, there were few ships of the large classes built. In the years 1776 and 1777, only a small number ot the ships which were introduced into the British navy, were above the sixth rate; but as the war advanced, the number of ships of the superior classes which were launched, gradually increased: still, as the energy of the nation was not exerted until war was declared against France, so neither were the resources of production for carrying on the war tried, until it assumed a more formidable character. To the continued building of small ships for cruising on the coast, was then added the building of ships of the line; and when peace was concluded, there were many ships of war in progress of building, both in the royal dockyards, and in private yards. These, as they were launched, during the several years that peace prevailed, produced a constant increase of the navy, which was very considerable, in ships of the line, besides those of inferior rates, which, however, were not very numerous.

The variations which were made in the dimensions of ships of the line within about thirty years, may be seen by the following examples:

Date.	Name.	No. of Guns.	Length on Gun-deck		Length of keel.		Extreme breadth.		Depth in hold.		Burthen in tons.	Proportion of breadth to length, as
			Feet.	Ins.	Feet.	Ins.	Feet	Ins.	Feet	Ins.		
1756	Royal George .	100	178	0	143	5½	51	9½	21	6	2041	1 : 3.43
1788	Royal George .	100	190	0	156	2⅜	52	5½	22	4	2286	1 : 3.62
1759	Sandwich . .	98	176	1	145	8	49	1½	20	11½	1869	1 : 3.59
1788	Prince. . . .	98	194	6	163	6	49	0	21	0	2088	1 : 3.97
1757	Norfolk . . .	74	165	6	134	4¼	46	8	19	9	1556	1 : 3.54
1787	Swiftsure . . .	74	168	9½	137	11¾	47	0	19	9½	1621	1 . 3.59
1760	Essex	64	158	1¼	129	6⅜	44	8¾	18	10	1379	1 : 3.53
1783	Stately. . . .	64	160	0½	131	7	44	6½	19	0	1389	1 : 3.6

In 1780 the *Minerva*, a thirty-eight gun frigate, was launched;—she was the first ship of that class that was built in England. Two ships of that class had been taken from the French,—the *Danae* in 1759, and the *Prudente* in 1779; the first of these was forty-four tons larger than the other,—measuring 941 tons; and the *Minerva* measured 938$\frac{72}{94}$ tons. The *Fortunee* of the same rate was captured in 1780; and her principal dimensions, as given by Charnock, are shewn with the other three already mentioned.

NAMES.	LENGTH.		Extreme Breadth.	Depth in Hold.	Burthen in Tons.	Proportion of breadth to length, as
	On the Gun-deck.	Of the Keel.				
	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.		
Danae . . .	147 6	123 11	37 9⅛	11 4½	941	1 : 3·9
Prudente . . .	136 0	118 11	37 9¾	10 10	897	1 : 3·59
Minerva . .	141 0	117 0⅜	38 10	13 9	938$\frac{34}{94}$	1 : 3·63
Fortunee . .	143 6	124 6½	37 10	12 2½	948	1 : 3·79

Four other ships of the same class,—the *Arethusa, Latona, Phaeton,* and *Thetis,* were built within the two following years, varying but little in dimensions and burthen. Frigates of this class, having been once introduced into the British navy, were approved; and they came into general use after the war broke out between England and the French republic; but their tonnage was then increased; and those which were built after 1794 generally exceeded 1000 tons in burthen. Associated, in point of time, with the introduction of the thirty-eight gun frigate, was the revival of the use of that of thirty-six guns. Several ships of this class were captured from the French and Spaniards in 1779 and 1780; the largest of those taken from Spain being 992 tons: and those which were afterwards built in England, down to 1784, varied in burthen between 869 and 890 tons. After this period, the length of this class of ships was considerably increased, which raised their burthen to 930 tons, on an average: a few only of that class were built during the period of the peace. From the time the general peace was concluded in 1783 till the war broke out in 1793, the British navy was called into little service that supplies interest to history; and was subject to few casualties of material importance.

By this time the navy of France had been improved, and it was now in a respectable condition, consisting, according to our Naval Historian,* of eighty ships of the line, in a serviceable condition, at the beginning of the year 1793; and of seventy-nine frigates from forty-four to twenty-eight guns, in various conditions. Fourteen of the ships of the line, and seven of the frigates were new ships.

The building of ships was carried on throughout that period; and as the character of the navies of France and Spain was such that they could be met on equal terms only by a large number of British ships of the line, so the building of large ships during the peace was made to increase the capabilities, and improve the condition of the British navy, against the emergencies for which it was apprehended it might be required.

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* James's Naval History, Vol. I. pp. 541-3.

The following list given in "Derrick's Memoirs," will show the "State and Condition of the Navy on the 1st December 1792."

RATES OR CLASSES.	Guns.	In good condition in ordinary.	At sea or in commission for sea service.	In want of repair.	Not surveyed.	Building or ordered to be built.	Repairing.	Total.
First	110	—	—	—	—	2	—	2
	100	5	—	—	—	—	—	5
Second . . .	98 & 90	11	2	2	—	5	1	21
Third . . .	80	1	—	—	—	2	—	3
	76	—	—	1	—	—	—	1
	74	30	9	21	—	3	6	69
	64	16	1	22	—	—	—	39
Fourth . . .	60	—	—	1	—	—	—	1
	52	—	—	1	—	—	—	1
	50	2	5	7	—	3	2	19
Fifth	44	8	1	11	—	—	1	21
	40	1	—	—	—	—	—	1
	38	3	1	2	—	—	1	7
	36	7	2	3	—	—	2	14
	32	14	10	15	1	3	7	50
Sixth. . . .	28	3	7	15	—	—	3	28
	24	—	3	2	—	—	1	6
	22 & 20	1	1	5	—	—	—	7
	12	—	1	—	—	—	—	1
	Total .	102	43	108	1	18	24	296

Total number brought down,	296
Sloops rigged as ships	30
" " as brigs	11
Brigs	6
Surveying vessel	1
Bombs	2
Fireships	9
Storeships	2
Armed vessel	1
Carried forward	358

Brought forward	358
Armed tender	1
Tenders	4
Vessels rigged as sloops	2
Cutters	19
Armed schooners	3
Hospital ship	1
Yachts	11
Hoys, lighters and transports	50
Receiving ships	16
Hulks	10
General Total	475

And as two of the ships under the head of "Building" were then finished, there were seventy-seven ships of the line at that time "lying up in good condition, at sea, or in commission for sea service, or on the stocks completely ready for launching; besides seven under repair, some of which were in a state of forwardness."*

This was, therefore, nearly the state in which the British navy stood when the war of the revolution broke out in the beginning of the year 1793.

In December 1790, the *Hibernia* of 110 guns was ordered to be built at Plymouth, and the *Ville de Paris* of 110 guns at Chatham. These were the two first ships mounting 110 guns built in England. The *Hibernia* was launched in 1804, and the *Ville de Paris* in 1795;—the dimensions of these two ships were as follows:—

	Length on gun Deck.	Breadth Extreme.	Depth in Hold.	Burthen in Tons.
Hibernia....	201 ft. 2 in.	53 ft. 1 in.	22 ft. 4 in.	2508.
Ville de Paris	192 .. 2 ..	53 .. 2½ ..	22 .. 2¼ ..	2351.

And their armament was established to carry on the lower-deck, thirty 32 pounders; middle-deck, thirty 24 pounders; on the upper-deck, thirty-two 18 pounders; and on their quarter-deck and forecastle, eighteen 12 pounders: whereas, the *Britannia*, built in 1762, the *Royal Sovereign* built in 1786, and the *Royal George*, built in 1788, each carried 100 guns; they had on their lower-deck, twenty-eight 42 pounders; on their middle-deck, twenty-eight 24 pounders; on their upper-deck, thirty 12 pounders; and on their quarter-deck and forecastle, from twelve to sixteen 12 pounders. This armament for 100 gun ships, appears to have been proposed in 1716,—except that, till the year 1762, they had from twelve to sixteen 6 pounders on their quarter-deck and forecastle. *The Royal Sovereign* was changed from 42 to 32 pounders on the lower-deck in 1793, while some of the ships of 100 guns continued the 42 pounders on their lower-decks till 1804;

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* Derrick, p. 198.

but soon after this, the whole were exchanged for 32 pounders, and guns of this size were found to be loaded and worked much quicker, and to a greater advantage in action.

In 1792, Sir William Rule, then surveyor, added to the navy, by the launch of the *Acasta*, one of the largest frigates built in England. The *Acasta* mounted forty guns: thirty 18 pounders on the main-deck, and on the quarter-deck and forecastle, ten 9 pounder long guns, which remained until carronades were introduced; when she was armed on the quarter-deck and forecastle with four 9 pounder long guns, and sixteen carronades of 32 pounds. This ship was intended to take the place of the forty-four gun ships on two decks. Her dimensions were as follows: length on deck, 154 feet; breadth extreme, 40 feet 9½ inches; depth in hold, 14 feet 3 inches; and burthen in tons, 1142. Sir John Henslow next followed, in the launch of the *Cambrian*, in 1797.

Many statements and opinions bearing a highly important relation to the interests of the navy, and embracing those interests on a very comprehensive scale, were given on different occasions by Mr. Snodgrass, who had been many years surveyor of shipping to the Honourable East India Company;—as in his evidence before a committee of the House of Commons in 1771, in his evidence before the commissioners of land revenue in 1791, and in a letter, in 1776, to the Right Hon. Henry Dundas, one of the secretaries of state, and president of the board of commissioners for the affairs of India. As his observation had been very extensive, and as his opinions were generally sound deductions from his experience, observation, and comprehensive knowledge, and are therefore still interesting, a digested view of his most important remarks are here presented to the reader.

We will notice, first, his opinion of the capabilities of the country to supply timber for the service of the navy. He considered that the forests and crown lands could, in the course of thirty or forty years, be made to yield a sufficient quantity of oak-timber to meet the constant demands of the dockyards for this article; or if such should not be the case, he recommended the purchase of waste lands consisting of clayey soil, and the planting of them with timber trees, allowing in every case the trees to reach their maturity before they were felled. And he gave it as his opinion, that there were sufficient lands lying within forty or fifty miles of water-carriage in the different counties, to yield such a produce of shipbuilding timber, if the whole should be managed to good advantage, as to render England permanently independent of foreign countries for the supply of this material. It is a matter of regret that his views on this important subject did not lead to more extensive practical results: but it is highly probable that they led to the forming of more comprehensive views relating to the native production of timber, than might otherwise have been entertained by the commissioners of woods and forests.

For, according to the report of the commissioners of woods and forests in June 1812, the expense of enclosing, planting, &c., ground for the growth of timber, would be about £5 an acre. It was also stated, that eighty oak trees might grow on an acre. The estimate of expense, is not, however, quite correct; for the expense of enclosing would diminish, as the quantity of land enclosed became greater. It would be found too, that a large oak of sixty years' growth would require eighty-eight square yards; and the quantity of timber which trees of this age bear, on an average, is from sixty to seventy feet. Taking this, now, as data, and the average meetings to be worth about £7 per load, it would result, that after deducting from the proceeds the expense of planting, admitting the first outlay to have been £5 per acre, that of repairing fences, &c., and allowing for the value of rent, the annual profit would be £8 on each acre, continued through sixty-five years.

In making this estimate, it is supposed that the trees will be at first a yard apart, and thinned every ten years,—yielding poles, small timber, bark, &c., of the value of £240; and finally, at the end of sixty-five years, if the plantation had been well managed, sixty-six loads of timber, making a total value of the produce of an acre £700, whilst the expense of planting, keeping up enclosures, interest of money, and rent would not exceed £150, leaving a clear annual profit of at least £8 an acre.

The value of the timber to the state is, however, of far more importance than the profit; and the value of the produce is increased by judicious attention to the selection and to the times of felling it, so that the timber may be cut down in its best condition. These statements of profit are taken at a low estimate; and the statement of expenditure, cultivation, &c., are drawn from the best authorities, as Arrowsmith, Dr. Beaufort, Newenham, Chalmers, and others. It also appears that there are more than 13,000,000 of acres of waste land that might be cultivated for the growth of timber; and although to several species of timber trees there is a peculiar adaptation in some conditions of the soil, yet there is good authority to believe that oak will grow on almost every soil: which even Evelyn appears to admit. If therefore the cultivation of this species of timber trees should engage the attention which the subject deserves, every waste corner, hedge-row, and bank of a river would soon be planted with this valuable species of tree; and in a few ages, our posterity would realize a complete independence of foreign supplies of oak-timber. But if private enterprise should not be called forth in this respect to the extent which may be considered desirable, still, the cultivation of large tracts of waste land remains to be considered as a matter of national interest, against which we see no valid objection.

It appears by a statement laid before Parliament in 1797, that from the time of the accession of queen Anne to that period, there had been 1776 bills brought in for enclosures, the average enclosure under each bill being 1769 acres; and in the twenty years following that date, there were 1870 bills, making the total number in the 115 years, 3646: and the whole quantity taken in, by virtue of all these bills, gives an average annual enclosure of 27,819 acres. Now, according to the parliamentary report for June, 1812, already mentioned, forty trees grew on an acre, and the average produce was rather more than a load of timber to each tree at sixty years' growth; or about sixty-six loads on an acre, or, an acre produces about a load of timber in a year. Hence, if the quantity of land enclosed under the bills above mentioned were regularly and successively planted, there would be an annual produce of 52,362 loads of timber. From these statements it appears, that if proper attention were paid to the cultivation of oak trees, the propriety of the opinions expressed by Mr. Snodgrass in 1771 and 1791 would be verified. And it must be evident that whilst the navy constitutes the principal basis of our national strength, it is a matter of vast importance that land should be cultivated to supply materials for its construction, rather than that it should remain unproductive altogether. But the capabilities of the country for the growth of timber can never be fully developed by legislative measures, separate from private interest and patriotism, which, pervading the nation, should combine with public regulations to turn to the best account the productive force of the soil.

It would not be proper here to do more than point out the important advantages and the practicability of the plan suggested. Nor would we offer a hint that could be construed to vindicate the propriety of legislative interference with private transactions, the interests of which are, it is believed, generally prosecuted with the greatest advantage, whilst there is entire freedom of choice and sound discretion regulating a spirit of liberal enterprise. As to the advantage of cultivating land for the growth of timber trees to a very great extent on private estates, it must be allowed that, in making plantations, a proprietor must consent to merge his present interest, and yield up to his heirs the benefits of his own discretion; whilst they might bear a favourable relation to him and to the state in general. At the same time it may be hoped that whatever legislative measures have been taken, to promote the cultivation of timber trees as a national undertaking, may be carried out with full force and efficacy to coming ages; so that the forests and plantations of our country may supply the surest means of constructing and maintaining a navy, and, according to the words of Mr. Snodgrass, "effectually prevent the want of that article for the navy, in future."

In the evidence which Mr. Snodgrass gave, as already mentioned, in 1771 and 1791, there were several important statistical facts mentioned. Amongst these, we find that the consumption of timber for the navy from the year 1771 to 1791 was double of what it had been from the year 1751 to 1771; that the East India shipping, of British build, increased in tonnage, from the year 1771 to 1776, from 45,000 tons to 79,913 tons: and that the price of building East India shipping had increased from 20*s.* to 40*s.*

per ton, principally in consequence of closer contracts, and of their being more substantially built.

In 1771, two East India ships of 864 tons burthen, were built for £10 10*s*. per ton, whilst a sixty-four gun ship of 1396 tons was built in a private yard at the cost of £16 12*s*. 6*d*. per ton. In 1800, ships of the line cost £21 per ton building; and in 1805, as much as £35 to £36 per ton was given. The price, however, from 1807 to 1810, was only £33 10*s*. East India ships of 1200 tons cost, in 1800, £18 18*s*.; in 1801 and 1805, £22; in 1809, £26; in 1811, £27; and in 1824, £18 16*s*. 6*d*. per ton.

Mr. Snodgrass pointed out the relation between the tonnage and the cost of ships. And in illustrating his statements on this subject, he stated that if two India ships of 600 tons, and one of 1200 tons were built, it would be found that the two small ships had consumed nearly three-fourths more in number of oak trees than the large one: hence, the building of small ships must increase the demand for young growing trees, and diminish the sources of supply of large full grown timber. It may be necessary to observe here, that as to the economy of timber, the illustration of Mr. Snodgrass must not be admitted *to the extent* to which it may at first *appear* to be applicable. Much, tending to modify the fact he stated, depends on the falls of timber: in many falls there is a great proportion of smaller timber; and owners of land, frequently, for the sake of clearing their lands, or for pecuniary considerations, fell their timber before it is fully grown: so that a large proportion of the timber which is cut is not allowed to arrive at its full growth, no regard being had to the wants of the ship-builder, nor any respect to the adaptation of the timber to particular purposes. Hence, there will always be a good supply of timber of moderate growth, irrespectively of any particular demand. The timber which it is the most difficult to obtain for the Royal Navy, is curved timber, and large timber for beams, stern-posts, &c.

Mr. Snodgrass adduced in support of his statement, that between the years 1771 and 1791 the price of timber under forty feet meetings had increased in price *fifteen* shillings a load, whilst timber of sixty feet meetings had increased only *five* shillings. He regarded this difference in the increase of price as conclusive evidence that there had been a greater demand for small timber than for large; but the inference to be deduced from this fact, must depend on two circumstances: — the state of the falls, and the demand occasioned by the increased number of ships built.

In the course of replying to the questions of the commissioners, Mr. Snodgrass advanced the opinion, that it was not good for the service that three years' stock of timber should be kept in the dockyards, on the ground, as he considered, that the timber would deteriorate by being kept. There is no doubt that the preservation of timber in store must depend in a very great degree upon the manner in which it is stowed, and the means used to season it and to protect it from exposure to extreme changes of the weather: and it is probable that his opinion may have been supported by observations which he had made, when the same means were not employed to protect the timber as are used in the present day. But, on several considerations, it appears desirable to have always a good stock of well seasoned timber in the dockyards; since the seasoning of timber requires time, which cannot be ensured except by having a good stock already sufficiently seasoned. There is no doubt that timber may be kept too long; but the deterioration of timber through keeping takes place in the absence of housing, and of those protective means by which timber should be screened from too strong currents of air, in the course of its becoming seasoned, and subsequently. He further gave it as his opinion, that rough timber becomes injured by being kept piled together. Now it is very possible to keep it too long in that state; but it is certainly useful to have a quantity of rough timber at least partially seasoned, that timber of particular curvature may be selected as it is required, which frequently cannot be obtained from sided timber. This often obviates the necessity of mixing very green with well-seasoned timber, in building ships,—a practice which should always, if possible, be avoided. But, for the convenience of selection, rough timber should be spread upon the ground when such an arrangement is practicable, rather than piled together, whilst that would at the same time conduce to its preservation. Timber should not remain more than two years in its rough state; but as soon as the sap, or wood not fully elaborated, is decayed, the timber should be sided. And Mr. Snodgrass considered that timber ought always to be cut to its proper shape as near as convenient to the place where it grows. If this were practicable, it would be most desirable, as it would be in a better state for seasoning, the cost of conveyance would be much less, and there would be far less risk of receiving unsound timber. He considered the loss on the conversion of rough timber to be about one-half in private yards, and something more in the government dockyards. Experience shows that in the dockyards, the loss does not generally exceed that quantity; and in the English sided timber, the loss is about two-fifths; while in the Italian it is much less. He recommended that converted timber, thick-stuff, and plank should be placed under cover, in such a manner, that the whole might be capable of receiving a moderate current of air,—too strong a current should be excluded, as it is injurious to such timber;—and his recommendation appears to have been subsequently attended to.

It has been observed, that Mr. Snodgrass did not think it expedient to keep a large stock of timber in the dockyards; instead of this, he recommended that timber should be converted as soon as it was received; and then be seasoned as it stood, composing the frames of ships, under a roof sufficiently large to cover the whole ship. The views held by Mr. Snodgrass at that time, were subsequently entertained by many experienced ship-builders; but they were not carried into full effect until some time afterwards, when the roofing over docks and ships became general in the government dockyards.

General Bentham proposed the housing over of docks, in such a way as to have within them efficient means of warming, ventilating, and artificially lighting the interior. And it may be hoped that some safe and convenient method of lighting will be introduced into these establishments before the exigences of the service shall again require it; for, the means which were used during the last war, when it was necessary to work late, — as the burning of torches, tar-barrels, &c., to produce a light for the men to work by, on the outside of ships, cannot but be deemed very dangerous in a place where so large quantities of combustible materials are on every side. It was proposed also that there should be, in the vicinity of the slips, steam-kilns for bending the planks, and machinery for performing the most laborious operations of work in those places; but it appears that these suggestions, which certainly would have been of great public benefit, were not entertained, on account of the expense.

As it regards the covering of docks and slips, it may be remarked that the practice had prevailed at Venice for a very long period before it was introduced into this country; as appears from the evidence given before the commissioners of land revenue by Mr. Strange, who was consul there in 1792: he stated also, that twenty-two large ships had been on covered slips, — some of them for nearly sixty years. In Carlscrona, there were also several covered docks, previously to their being introduced into the dockyards of England; and both Mr. Nicholls and Mr. Snodgrass recommended the building of roofs, nearly thirty years before any were constructed in our dockyards. Perhaps no improvement in these establishments has had a more decided tendency to preserve the timber and add to the durability of ships, than the building of roofs over docks and slips; at the same time, that it has added immensely to the comfort and convenience of the men employed on the ships beneath them.

Before the breaking out of the French revolutionary war, several ships had been covered over with a slight housing, which was removed when the ship was launched. And in the year 1792, the fore and after parts of ships were covered over, as the fore and after deadwood and stern-frames, to protect the heels of the fore and after cant timbers whilst the frame was standing to season.

With respect to the repairing of ships, Mr. Snodgrass, in the course of his evidence, gave it as his opinion, that in point of economy, there was a great mistake in giving ships very extensive repairs; and stated, in support of his opinion, that many a ship has cost as much, under a thorough repair, as two new ships. He recommended that ships should have slight repairs, and be strengthened with iron riders and standards if they were needed, but not have the timbers of their frame shifted. There are few shipwrights who, on maturely considering the economy of repairs, would

ALTERATIONS PROPOSED BY MR SNODGRASS.

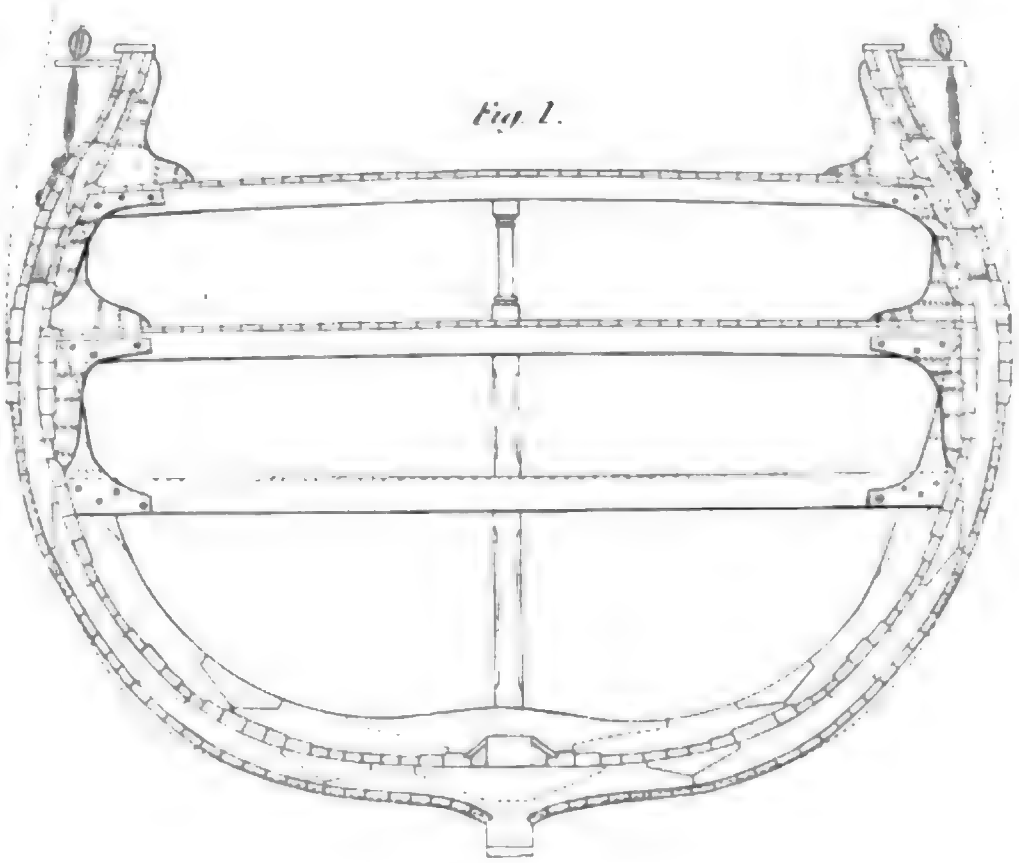

Fig. 1.

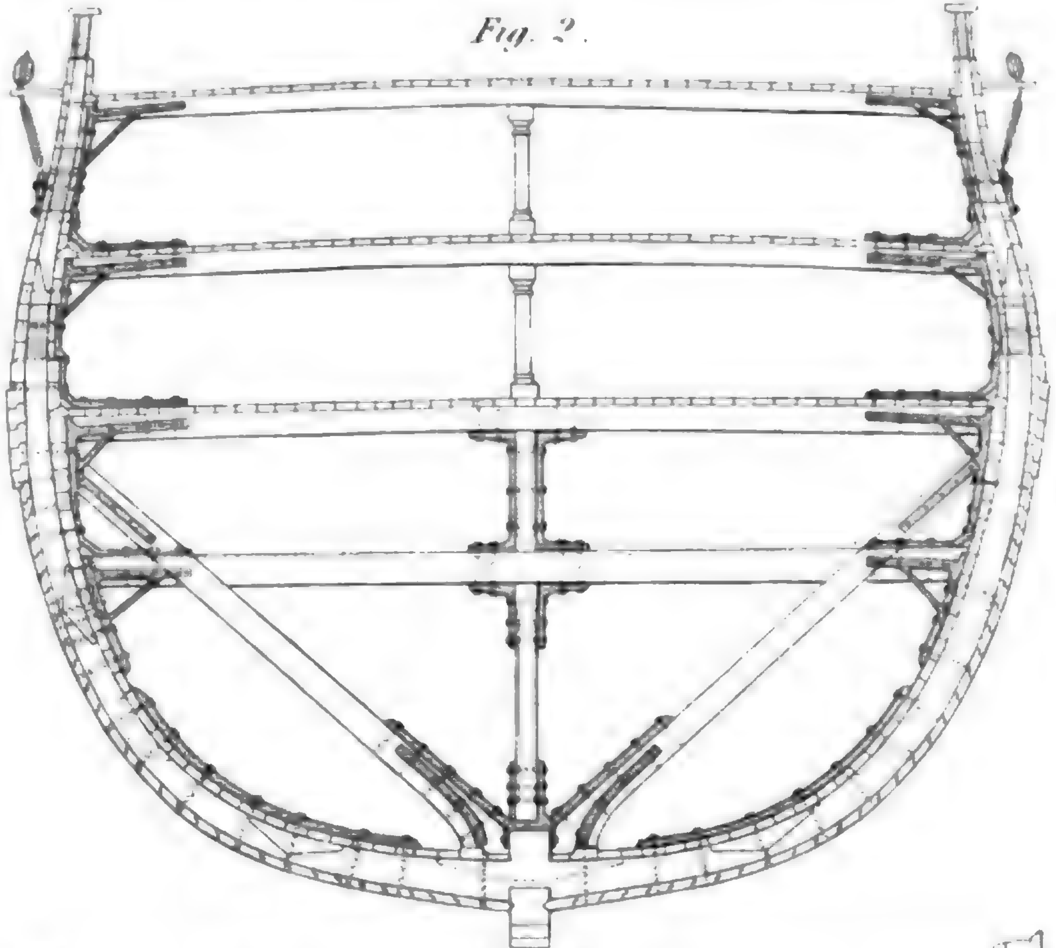

Fig. 2.

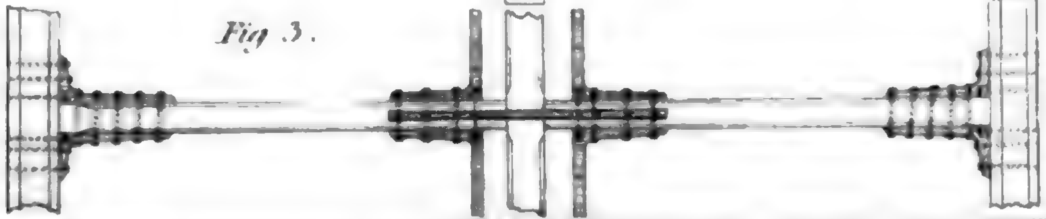

Fig. 3.

not agree with Mr. Snodgrass, that large repairs are often attended with a wasteful expenditure of materials and labour; whilst the timbers left in the frame cannot generally be expected to last so long as the new materials; but may, very probably, tend to induce decay in them. Still, there are often timbers found prematurely decayed, owing to causes which it is not easy to ascertain; and if such timbers were not removed, they might spread decay to a very serious extent. This makes it desirable that in forming and combining the different parts of a ship, they should be so disposed, that defective parts may be removable with the least possible difficulty. This forms a great objection to the iron plates that have of late been let into the frames of ships, because, as they cross several timbers of the frame, as well as many strakes of planking, a defective timber cannot be removed without great trouble and expense.

Now, although it must be admitted that the expense of thorough repairs is often very great, and in some cases it exceeds perhaps what ought to be incurred in the repair of an old ship, yet, the author is not aware that any case such as Mr. Snodgrass mentioned, ever occurred in the government dockyards. If the expense of thoroughly repairing any ship amounted to the cost of building *two* ships, it was more likely to have taken place in a private yard than in any of the national yards; as the repairs of ships of the navy, both previously and subsequently to his time, have cost much less than their first expense.*

Mr. Snodgrass further gave his opinion on several points in the construction and building of ships. With regard to the form of the side, he objected to the tumbling-home, which in his day was carried to excess; and he proposed the alteration which is shown by the dotted line in the comparative sections (*Plate* 19, fig. 1.) The advantages of a wall-side over that with a tumbling-home, is, that it gives more room on the gang-ways and quarter-deck for working the ship; and reduces the curvature of the fourth futtocks and top timbers. Since that time, the degree of tumbling-home has been very much diminished; and the moderate curvature given to the top-sides of ships of the present day, is undoubtedly the best that has yet obtained in the navy, with regard both to the convenience of getting timber of the proper degree of curvature, and also to the working of the ships, for which it allows ample room. For, whilst the excessive tumbling-home was subject to very serious objections, so also, in the royal navy, would be the extreme of upright sides which is given to the ships of the East India company; since, in ships of war, having to carry heavy guns on their upper decks, there would be a greater tendency in the top-sides to work, and in the ships, to labour.

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* We find that the *Royal William*, built in 1719, cost in building, about £30,794, and when reduced in 1757, from 100 guns to 84 guns, cost for repair £20,981; and during a period of twenty-five years, had three repairs, which cost £14,037.

The *Royal George* (*Plate* 16 *b*), built in 1756, cost in building, £54,664: she had a large repair in 1768, at an expense of £39,031, and between this period and 1782, had four repairs, which cost £18,626. The *Foudroyant*, which was taken from the French in 1758, had a large repair at Plymouth in 1774, costing £32,606, and had three repairs between this period and 1780, at an expense of £12,721. Many more statements might be given on the repairs of ships; but, in no instance do we find that any single repair cost more than the expense of building.

It was considered good policy for many years after Mr. Snodgrass gave his evidence, that if the floor timbers could be saved, on account of the scarcity of large timber, it would be proper to repair a ship; but for some years, repairs have been carried on more economically, by more extensively piecing defective timbers in the frames of ships; nor can it be considered economy to repair a ship, if the total expense should exceed one-half of the original cost of her building.

Mr. Snodgrass appears to have been the first to suggest the use of iron for knees and standards, instead of wood. It is probable, that his motives for this alteration, may have arisen from considering the difficulty there was in obtaining knee-timber, and also the importance of strength and compactness, whilst iron is less cumbersome than wood for such purposes (see *Plate* 19, fig. 2). The difficulty of obtaining knee-timber, was experienced very much a few years afterwards; and it led to the proposal of several plans with the view to obviate the inconveniences of this difficulty: but these will be stated in another part of this history.

Mr. Snodgrass proposed also, the use of diagonal braces, which should extend from the keelson to the gun-deck beams. (*Plate* 19, fig. 3.) This plan was tried in some of his majesty's ships, and in the *Orion* of seventy-four guns, in the year 1805. One end of the braces was attached to the keelson—an almost immoveable point, and the other end was attached to the side; and hence, at every alteration in the transverse form, especially when the ship was rolling, a motion took place tending to separate the side from its connection with the beams. As these braces were not found to answer the purpose for which they had been proposed, they were discontinued in ships of the royal navy.

With respect to the building of ships, Mr. Snodgrass gave it as his opinion before a committee of the House of Commons, that it would be better for government to have ships of war built by contract in private yards in the time of peace; so that more ships might be built, with well-seasoned timber, in readiness when required in war; and also that the shipwrights in private yards might have constant employment, and, therefore, a sufficient inducement to remain in the country. He was of opinion, that if ships built in private yards had as much time to become seasoned, as those built in the king's yards, they would be the most durable; since, as he stated, private builders use sounder and better timber than that obtained in government yards. This opinion has been held since; as it is considered that private builders often obtain the first choice of timber after the falls.

In connection with a notice of this recommendation, it may be mentioned, that in the eleventh report of the commissioners of land revenue, and in an appendix to the report, it is stated that the commissioners of the navy, in answer to their inquiries, have given their opinion that, on an average, the ships built in the king's dockyards would last fifteen years; whilst those built by contract would last only about ten years. The greater durability of the former, they attributed to the timber being better seasoned, and also to their being longer in building,—a circumstance which would contribute greatly to their durability. In several cases which have taken place since that time, the opinions of the commissioners have been borne out; but at a later period it has been shown, that several ships that had been built in private yards in the time of the war, were more durable than had been admitted in that general estimate, while the contrary has likewise been the case. From the commencement of the reign of George the Third, to the year 1791, the ships built by contract, and those purchased, amounted to 256,656 tons, whilst those built in the national dockyards, amounted only to 131,852 tons; and during this time, the mean duration of ships of the navy did not exceed twelve years.

In December 1792, when from circumstances connected with the French Revolution, a war broke out between that nation and England, the latter had only twelve ships of the line in commission, and thirty ships from 50 to 20 guns. But by the remarkable vigour with which the duties of the dockyards were carried on, there were, by September 1793, seventy-one ships of the line, and one hundred and four ships from 50 guns downwards.

The high price which had been paid for stores, and the difficulty experienced in obtaining many of them on the breaking out of a war, induced the navy board, in 1783, to order that all new ships, and ships in good condition, should have a great proportion of their furniture and stores appropriated to them, and duly arranged in store; so that there might be no difficulty in fitting them out on an emergency: and, accordingly, lord Barham ordered an establishment of stores to be kept ready in the magazines of the dockyards; and it was under the advantages of the judicious arrangements made by the navy board in 1783, of appropriating stores to ships, and the regulations which originated with lord Barham, of forming an establishment of stores in the magazines of the dockyards, that the obtaining of stores for them, occasioned no delay in the equipment of the ships, on the breaking out of the revolutionary war.

The *Cambridge* and *Princess Amelia*, which were launched in 1754 and 1757, had 80 guns on three decks: when the length on the gun-deck of the *Cambridge* was only 166 feet, breadth 47 feet, and depth in hold 20 feet; and that of the *Princess Amelia*, 165 feet in length on gun-deck, breadth 47 feet 3 inches, and depth in hold 20 feet; and the tonnage of the *Princess Amelia* 1579, and of the *Cambridge*, 1615. And, at this period, there was an essential difference between the navy of England and the navies of France and Spain, the latter having no three-decked ships. Their largest ships appear to have been of 84 guns, but they were of large dimensions; as was found by the capture, in 1758, of the *Foudroyant*, a French ship of 84 guns on two decks, which ship had a length on the gun-deck of 180 feet 5 inches, breadth extreme 50 feet 3 inches, depth in hold 23 feet, and burthen in tons 1977. This led to the building of a better class of two-decked ships in England; and we do not find that any ships of 80 guns on three-decks were built after 1757,—nor any 70 gun ships after 1776,—nor any 60 gun ships after 1759. It was not till after the war that commenced in 1778, when the French having learnt that their 84 gun ships were inferior in combat to our three-decked ships, that they introduced three-decked ships into their navy; and, according to Charnock, the *Bretagne* was built 196 feet 3 inches long on the water-line, and 53 feet 4 inches in breadth, moulded; and her displacement 4660 tons; about 100 tons less displacement than that of ships of the present day. However, the *Bretagne* had greater dimensions than the English first rates constructed some years later, as no three-decked ship was laid down of these dimensions, till 1790; and, according to Charnock (Vol. III., p. 230,) an ordinance was issued in 1786 for establishing the dimensions of the French fleet, as given in the following table, which exceed the dimensions of English ships built in 1793; as we find the *Cæsar*, designed by Mr. Hunt and launched in 1793, was only 181 feet on the lower deck, 50 feet 5 inches breadth extreme, and 2063 tons; while the *Queen Charlotte*, launched in 1790, was only 190 feet on the lower deck, breadth extreme 52 feet 5½ inches, and 2286 tons; constructed likewise by Mr. Hunt.

WEIGHTS OF EQUIPMENT FOR SIX MONTHS SERVICE ACCORDING TO FRENCH REGULATIONS, 1786.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tns.	Tons.
Weight of ordnance......	496	489	375	314	200	131	86	39	3
Weight of the cordage and rigging independent of the masts	330	268	245	220	160	128	92	48	24
Water for three months ..	315	293	236	192	146	90	73	34	19
Weight of the butts or casks	52	49	40	32	24	15	12	5	3
Provisions for six months .	617	608½	447½	367½	278½	167¼	137	44	26½
Weight of the equipage ..	137	129½	104½	86	66	39	32	15	6¼
Stores of the captain & officers	64	58	35	30	25½	20	18	9	6
Clothing of the men, and weight of the boats..	40	36	30	25	20	18	15	13	9
Iron ballast	500	400	360	245	180	146	90	55	20
Stone or shingle ballast ..	195	164	148	100	80	60	24	18	10
Total weight of equipment	2746	2510	2021	1611½	1180	814	579	280	126
Total weight of hull, &c..	5246	4910	3825	3048½	2300	1479	1162	546	266

Principal Proportions of French Ships of War, according to the Ordinance of 1786.	Ships of					Frigates carrying		Corvettes	Advice-Bts.
	120 Guns.	110 Guns.	90 Guns.	74 Guns.	64 Guns.	18-pounders.	12-pounders.	Of 20 Guns.	Carrying four 4-pounders.
	Feet. Ins.	Feet.	Feet.	Feet. Ins.	Feet. Ins.	Feet. Ins.	Feet. Ins.	Feet. Ins.	Feet. Ins.
Length from head to stern	196 6	186—185	184—180	170 0	156 0	144 0	136 0	112 0	80 0
Breadth from outside to outside of the frame	50 0	49 6	48 0	44 6	41 0	36 6	34 6	28 4	24 0
Depth in the hold	25 0	24 6	23 9	22 0	20 0	18 0	17 6	14 4	12 0
Draught of water when light — abaft	17 6	17 4	17 0	15 8	14 6	12 6	11 3	9 6	8 4
Draught of water when light — forward	14 0	13 8	12 0	10 10	11 1	8 7	8 6	8 5	8 0
Draught of water when laden — abaft	25 0	24 8	22 6	21 6	19 9	16 0	15 4	13 3	11 6
Draught of water when laden — forward	22 8	22 2	21 0	19 10	18 9	15 2	13 9	11 9	10 0
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Total weight of the ship and stores when victualled and furnished for a six months' cruise	5246	4910	3825	3548½	2300	1479	1162	546	266
Difference between ships of the same class	237	210	126	115	65	52	44	23	22
Weight of the fluid displaced, when light, measured by the inch	23½	21	19	15⅔	12¾	11½	9½	6½	4¾
			Tns. cwt. lbs.	Tns. cwt. lbs.		Tons. cwt.			
Displacement when laden, measured by the inch	29	26	22 1 23	20 4 19	16½	13 7	11¼	7½	3½
	Feet. Ins.	Feet. Ins.	Feet. Ins.	Feet. Ins.	Feet. Ins.	Feet. Ins.	Feet. Ins.		
Height of the lower battery from the surface of the water	5 4	5 0	5 6	5 6	5 0	6 0	6 0	—	—
		Nature of the Guns, *i.e.*, weight of their respective Shot.					Number and calibre of Guns.		
Weight of metal. — Lower tier on battery	32 36	30 36	30 36	28 36	26 24	—	—	—	—
Weight of metal. — On the middle	34 24	32 24	—	—	—	28 18	26 12	—	—
Weight of metal. — On the upper	34 12	32 12	32 24	30 18	28 12	—	—	—	—
Weight of metal. — Quarter-deck and forecastle	20 8	16 8	18 8	16 8	10 6	12 8	6 6	20 6	4 4
	Men.	Men.	Men.	Men.	Men.	Men.	Men.	Men.	Men.
Equipage — Numbers of the crew in time of War	1098	1037	839	690	623	314	261	120	50
Equipage — Numbers of the crew in time of Peace	764	727	581	472	354	222	181	120	50
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Weight of hull and masts	2500	2400	1804	1437	1120	665	583	266	141
	Feet. Ins.	Feet. Ins.	Ft. in. lin.	Feet.	Ft. in. lin.	Feet. Ins.	Ft. in. lin.	In. lin.	In. lin
Height of the centre of gravity from the keel	13 6	13 0	12 7 5	$11\frac{48}{100}$	11 8 0	9 1	8 5 9	6 4	6 10
	Ft. in. lin.								
Distance of the centre of gravity from the centre of the vessel	2 3 6	1 4	1 7 10	$2\frac{58}{100}$	1 6 0	1 2	1 11 6	2 5	4 1
Height of metacentre above centre of gravity	12 4 10	12 0	12 2 0	$12\frac{16}{100}$	10 10 6	11 8	10 8 9	8 9	6 8

It was through the ordinance issued by the French in 1786, that the English ships constructed and launched about the years 1793 and 1794 had increased dimensions, though it was not till after the capture of several French ships, that their superiority was manifest, and that we began to copy more from them.

When it became known in England that the king of France had been executed, the government ordered the French ambassador to leave the kingdom; and a few days afterwards, a message was sent from his majesty to the House of Commons, "which in fact announced the commencement of hostilities against France."* But France anticipated the purpose of England by declaring war on the first of February.

In the month of March, government voted the supplies for the navy; when 45,000 seamen and marines were granted for the service of the year; together with the sum of £669,205 for the ordinary of the navy, and £387,710 extra for the building and repair of ships: and, as the spring advanced, active measures were taken to dispose of the naval power, in such a manner as to act most extensively towards defeating the objects contemplated by the French republicans; and with this view, a fleet was sent to the West Indies; and such regard was had to the supplying of foreign stations with fleets, that it was not until the middle of July, that a fleet adequate to the requirements of the channel could put to sea under lord Howe. But nothing material resulted during the year, from the employment of this fleet.

The most important consequences of naval operations during the year, resulted from the employment of the fleet in the Mediterranean under lord Hood, to whom the inhabitants of Toulon surrendered their city and the harbour, with all the ships it contained, on certain conditions of trust. It was not, however, by the mere act of surrender that the fleet lying at Toulon, came into the power of the English; for a considerable portion of the fleet was in the hands of the republican party. The fleet consisted of one ship of 120 guns, one of 80, fifteen of 74, seven frigates, and ten corvettes ready for sea; one of 120 guns, one of 80, two of 74, and a frigate, in the course of being refitted; nine ships of the line, five frigates, and two corvettes, lying in want of repair; and one 74 gun ship, and two 40 gun frigates were on the stocks unfinished. The French had likewise one ship of the line, twelve frigates, and four corvettes cruising in the Mediterranean.

The ships of the line brought away from Toulon by admiral lord Hood on the 18th December, 1793, were as follows:—

		Length on Lower Deck.	Breadth Extreme.	Depth in Hold.	Burthen in Tons.
Le Commerce de Marseilles ..	120 guns	208 ft. 4 in.	54 ft. 9½ in.	25 ft. 0½ in.	2747
Le Puissant ..	74 ,,	178 ,, 8 ,,	47 ,, 11½ ,,	21 ,, 10 ,,	1794
Le Pompee ..	80 ,,	182 ,, 2 ,,	49 ,, 0½ ,,	21 ,, 10½ ,,	1901

The English did not long hold possession of Toulon; and when they were compelled to evacuate the place, some of the ships were set on fire, and others remained to be repossessed by the successful republicans;

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* Campbell's History, Vol. VII., p. 300.

and the great haste with which lord Hood was obliged ultimately to quit Toulon, compelled him to relinquish the chief advantages, in point of weakening the French navy, that his former successes had promised. "Great Britain obtained only by the capture of Toulon, three ships of the line and five frigates; these being all that lord Hood was able to carry away."* A later historian states, that besides the three ships of the line, the English carried off twelve of inferior rates; but of these he says "few were worth much to their new masters."†

During this year, the British navy improved considerably in its effectiveness; and at the commencement of the year 1794, it had in commission eighty-five ships of the line, eight 50 gun ships, twelve of 44 guns, and ninety-eight frigates, besides inferior ships and vessels,—making a total of 279 ships and vessels in commission for sea service.‡ The sum granted for the ordinary of the navy, was £558,021: and that for the extraordinary expenses was £547,310; and, 85,000 seamen and marines were granted for the service of the navy.

The great naval event that distinguished the year, was the general engagement on the 1st of June under lord Howe, who gained an important victory over the French, when he captured six of their line of battle ships, and injured another so much that she sank in consequence of the shot-holes under water. In the Mediterranean, the island of Corsica was compelled by the English, under lord Hood, to capitulate: and, in the West Indies, several important islands were reduced by the English under vice-admiral sir John Jervis. But one of these, Guadaloupe, was a short time afterwards recovered by the French.

This year, there were captured from the French, the *Pomone*, of 40 guns, and the *Revolutionnaire* of 38 guns,—two of the finest frigates that had yet been in the possession of the English. The principal dimensions of these two frigates were as follows:

NAMES.	Length on gun-deck.		Extreme Breadth.		Depth in Hold.		Burthen in Tons.	Proportion of Breadth to Length.
	Feet.	in.	Feet.	in.	Feet.	in.		As
Pomone........	159	$2\frac{3}{8}$	41	$11\frac{3}{8}$	12	4	1239	1:3.79
Revolutionnaire..	157	2	40	$5\frac{1}{2}$	12	6	1148	1:3.88

The former of these ships is said to have been an incomparable sailer, and in every way excellent as a ship of war; whilst, as cruisers in the British service, the *Revolutionnaire* took the second place; and, not only in these frigates, but also in ships of the line captured during the year, the English obtained examples of enlarged dimensions. For no British ship of even the first rate had yet been built of so great a length as the French 80 gun ship *Juste*, which was 193 feet 4 inches on the gun-deck,—being 3·84 times her breadth. The *Sans Pareil*, likewise of 80 guns, which was taken by lord Howe at the same time, measured ninety-nine tons more than the *Juste*, being fourteen inches and a half wider, but only 193 feet in length.

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* Campbell's History, Vol. VII., p. 308. † James, Vol. I., p. 117. ‡ Ibid.

The British navy went on increasing in the number of its ships; and 100,000 seamen and marines were voted for the service of 1795. The sum of £589,683 was voted for the ordinary of the navy; and £525,840 extra for the building and repair of ships, and such other works as related thereto.

Many facts had demonstrated by this time, that French ships of war were superior, in point of sailing, to the English ships; and the attention of the nation was called to this subject by some remarks that were made upon it in the House of Commons, where some of the naval members appeared unwilling to allow to the enemy that superiority on which other members strongly insisted; and admiral Gardner attributed it to the liberality of the French government to constructors, in granting premiums for the best models they could produce. It was urged, however, in admitting that the French ships were better sailers than the English, that our ships were better built. But, whatever excellence attached or was peculiar to the work of British shipwrights, still as the other excellence might be conjoined to this, and the ships be rendered superior cruisers, as well as good ships in action or in a storm, the suggestions which the remarks on the comparative character of English and French ships of war elicited, deserved, at such a time as that, the most attentive regard of the government; and, in order to improve the sailing qualities of ships of war, it was deemed requisite to give them a greater length in relation to their breadth. The further improvement of raising the lower battery of ships of the line higher out of the water, was now also resolved on: however, the restriction of constructors to small dimensions in relation to the force, was one of the principal causes of the failure of the sailing of our ships; and it will be seen by a reference to different parts of this history, that French ships in all cases exceed the English in their principal dimensions.

The number of ships in commission as cruisers during the year, was something greater than it had been in the preceding year. But the French had grown more cautious with regard to the exposure of their fleets; and no general engagement took place between the British channel fleet and that of the French, at Brest. In the Mediterranean, however, the fleet from Toulon, and that under vice-admiral Hotham, were both active in cruising; but still no engagement appears to have been brought on, even partially, by the joint resolution of the opposing commanders; and the British admiral has been regarded as failing to take prompt advantage of the circumstances of the enemy's fleet.

In the meantime, the British navy continued to improve in its efficiency. The number of cruisers was increased, during the year, by fourteen ships of the line, and thirty-six of inferior rates, and the entire naval establishment was increased by no less than eighty-two ships and vessels. But Holland had been reduced by the French, and become united in their interest in the war; and Prussia had made a separate peace with France; whilst the professions of friendship on the part of Spain were thought to be of doubtful continuance.

Under these circumstances, it was considered requisite to increase the establishment for the year 1796; and 110,000 men were granted to serve in it: and the sum of £624,152 was voted for the ordinary expenses of the navy; and of £708,400 for the building and repair of ships of war.

The great preparations which it was known the French were making at Brest, whilst the immediate object of those preparations was not known, rendered it necessary to alter the arrangements with respect to the fleet in the channel: but, notwithstanding the division of this fleet into three squadrons, the more certainly, it was thought, to defeat the designs which were contemplated by the French, their fleet sailed from Brest unobserved; though it failed in its object against Ireland.

In the Mediterranean, the events of the war turned most unfavourably for the interests of Great Britain. For Spain having declared war against England, fitted out a fleet to act in concert with that of France; and this combination raised the enemies' force in that sea decidedly above that of the English under sir John Jervis, who therefore retired to Gibraltar, leaving the undisputed possession of the Mediterranean to the fleets of France and Spain. With a prospect unfavourable to Great Britain, an ineffectual attempt was made for the restoration of peace, by sending a minister to Paris to negotiate.

During the year 1795, several ships had been purchased of the East India company to be fitted out as ships of war. One of these, the *Glatton*, was fitted out at Sheerness, and armed with twenty-eight 68 pounder carronades on her lower deck, and an equal number of 42 pounders on her upper deck; she was sent out in July, under the command of captain Trollope, to join a small squadron of ships in the North Sea. But, before the *Glatton* joined this squadron, she fell in with six French frigates, which were not long afterwards joined by a brig-corvette and a cutter, off the coast of Flanders. Captain Trollope observed that "the commodore's ship appeared to mount near 50 guns; two others appeared about 36 guns, remarkably fine long frigates; and the other three, smaller." It was about ten o'clock at night when the action began, at the distance of twenty yards from the opposing ships; the frigates having in the meantime formed themselves into the line. The *Glatton* had to engage her antagonists in a brisk fire "on both sides, for a few minutes, with her yard arms nearly touching those of the enemy on each side."* The action had not continued long in this way before the enemy were obliged to retire; and the *Glatton*, having been very much damaged in her rigging, was unable to follow in pursuit. The night was spent in repairing the damages, under some expectation that the French commodore would be willing to renew the action in the morning, captain Trollope hoping to be joined in the meantime by an English ship or two that were cruising. The commodore declined, however, any further contest, although followed by the *Glatton*, as he retired with his squadron towards Flushing. But notwithstanding the eminently successful employment of this heavy armament in the *Glatton* in her first encounter, no other ship was armed in the same way.

No ships of the line were taken from the French during the year; but several of their frigates fell into the hands of the English. A greater number of Dutch ships were captured, as were also two Spanish frigates.

Within the same period England sustained the loss of a considerable number of ships. Several ships of the line, besides others of inferior classes, were destroyed by fire, wrecked, or foundered; and a 10 gun brig was captured by a Spanish squadron in the Mediterranean.

The supplies voted to the naval service for the year 1797 were 120,000 seamen and marines; the sum granted for the ordinary of the navy was £653,573; and the extra sum for the building and repairs of ships, and of other necessary works relating to them, was £768,100.

At the beginning of the year 1797, there were 108 ships of the line in commission as cruisers; and 293 ships and vessels, from those of 56 guns, down to armed cutters; being an increase of three ships of the line, and twenty-two of inferior rates. At the same time the entire number of ships and vessels composing the British navy, including as well those which were on the stocks, and those which were only ordered to be built, as those which had a perfect existence in the naval service, was 172 of the line and 461 of inferior rates; being an increase realized during the preceding year of five of the line, and thirty-six under the line; whilst only one ship of the line, six small 36 gun frigates, eight large and six small 18 gun brig-sloops, had been launched within that time.

The close of the year 1796 and the beginning of 1797, were distinguished by a powerful attempt on the part of the French at the invasion of Ireland. The fleet was fitted out at Brest, and intelligence of its sailing was communicated to England by vessels that had been stationed for the purpose of gaining information. But so much time elapsed between the sailing of the fleet from Brest, and the British fleet under lord Bridport reaching the coast of Ireland, that though the enemy had been in

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* It is stated that the French frigates attempted to board, but that the rigging was cleared of the boarders by the grape shot from the 42 pounders on the upper deck, while the 68 pounders on the lower deck nearly beat in the sides of her opponents.

Bantry Bay, they had sailed again before his lordship arrived. Some of the enemy's ships, however, foundered in the bay; a few others were taken; and such of them as had been able, had sought their safety from the violence of the wind by getting clear of the coast before their pursuers arrived; and England was saved from alarm and danger by circumstances beyond her controul, that frustrated the designs of her enemies.

The French lost in this expedition thirteen ships; two of the line, four frigates, two corvettes, and five transports; the remainder of their fleet arrived in several of their ports between the first and the middle of January. And after this, the fleet at Brest remained inactive in the harbour, leaving the English channel fleet to cruise without an antagonist to encounter.

The first event that signalized the employment of the British navy, in 1797, was the general engagement between the Spanish fleet, and that under the command of sir John Jervis off Cape St. Vincent; in which the English gained an important victory, the fruit of which was four ships of the line. These were the following, of which the principal dimensions are given: —

NAMES.	No. of Guns.	Length on Gun Deck.		Extreme breadth.		Depth in Hold.		Burthen in Tons.	Proportion of breadth to Length.
		Feet.	in.	Feet.	in.	Feet.	in.		As
San Josef . . .	112	194	3	54	3	24	3½	2457	1:3.58
Salvador del Mundo .	112	190	9	54	3½	23	1½	2398	1:3·5
San Nicolas . . .	74	179	9½	49	7¼	20	1¼	1942	1:3·62
San Ysidro . . .	74	176	0½	48	11¼	20	1½	1836	1:3·59

These ships were immediately seen by their new owners to possess superior qualities, owing to the character of their construction. For it is said that, "under their jury-masts, and poorly manned as they necessarily were, they beat all the English ships in working into the Tagus."* All these ships, it will be perceived, had a greater breadth of beam in relation to their length than it was customary, either at that time, or than it has been since, to give to ships of war in the English navy.

In speaking of the defeat of the enemy's fleet off Cape St. Vincent, Charnock says, "Nor was this the only misfortune which befel the Spanish marine;

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* James's Naval History, Vol. II., p. 74. Although these were very fine ships, and superior to most ships of that time, yet, their superiority in working to windward, may not have been owing *entirely* to their essential excellence. For, ships not characterized by superior qualities, sometimes work to great advantage under jury masts, when they are light, and other circumstances are favourable to them.

for, three days only after the event just mentioned had taken place, one of their squadrons stationed in a distant quarter of the globe (the gulf of Paria on the coast of South America), was in a great part destroyed by the hands of those who should have defended it; one ship of 84 guns, two of 74, and a frigate of 36, being burnt by the Spaniards themselves, to prevent their falling into the hands of the British, as was the fate of the only survivor, a ship of 74 guns."*

In this year, the *Cambrian*, constructed by sir John Henslow, and the *Acasta*, by sir William Rule, were launched. These frigates were of large dimensions, and were intended to supersede the 44 gun ships on two decks: they were of the following dimensions:—

	Length on deck.	Breadth extreme.	Depth in hold.	Burthen in tons.
Cambrian	154 ft. 0 in.	41 ft. 3 in.	14 ft. 0 in.	1160
Acasta..	154 „ 0 „	40 „ 9½ „	14 „ 3 „	1142

The *Acasta* was armed with thirty 18 pounders; and the *Cambrian* with twenty-eight 24 pounders on the main-deck.—The *Acasta*, on the quarter-deck and forecastle, ten 9 pounders, and the *Cambrian*, twelve 9 pounders. The *Fisgard*, taken this year from the French, was six feet longer, and 1182 tons.

The other great event of the year, was the general engagement between the English fleet commanded by admiral Duncan, and the Dutch fleet, off Camperdown. This occurred in the month of October, after the Dutch fleet had been lying a considerable time in the Texel, and the English stationed off the coast to watch them. At length, when admiral Duncan had retired to Yarmouth for stores, leaving the coast clear, the Dutch fleet got to sea; of this event, information was soon conveyed to the British commander, who hastened to re-occupy his station. On the morning of the 11th the two fleets came in sight of each other; and each commander evinced a similar forwardness to render the engagement general. It began soon after twelve o'clock, and was sustained with great bravery on both sides; but the result was, a great victory gained by the English, in which the prizes were two ships of 74 guns, five of 64, two of 50, one frigate of 40 guns, and one of 32. The last ship was driven upon the coast of Holland, and was re-taken; one of the 50 gun ships sank in consequence of the shot holes, and the other was lost on a sand in a gale of wind. The other prizes, which were brought home, were never of any service in the British navy.

The only ships lost during the year 1797, were a small number of frigates, and a few sloops and gun brigs.

The increase in new ships was of far more importance. There were launched in the royal dockyards, the *Neptune* of 98 guns and 2111 tons, and the *Centaur* of 74 guns and 1842 tons; and a 64 gun ship was purchased. Besides these, there were launched in private yards forty-six frigates and smaller vessels, the largest of which was the *Endymion* of 40 guns, measuring 1277 tons, 159 feet 3⅜ inches long on the gun-deck, 42 feet 7⅜ inches in extreme breadth; and with 3.74 times the breadth to the length.* Five other frigates, four of 38, and one of 36 guns, six sloops, thirty-one gun-brigs, and one cutter were likewise launched; and eight bomb-vessels, eleven gun-brigs, and two cutters were purchased into the service. And thus, with the constant advance in the building of the inferior classes of ships, the number of light cruisers was much increased; for, whilst there were fewer by four ships of the line in commission at the beginning of 1798, than there had been twelve months before, there were more of those below the line by fifty-four ships and vessels; forty-two out of this number were gun-brigs, and sixty-five of this class of cruisers were at this time in commission. The total amount of ships and vessels at that time belonging to the British navy, including those which were in the course of building, and those which were ordered to be built, in connection with those in commission, and those which were lying inactive in harbour, was 696 ships and vessels, with an aggregate burthen of 581,458 tons; being a total increase of sixty-three ships and vessels, and of 30,910 tons.†

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* History of Marine Architecture, Vol. III, p. 237.

The supplies for the naval service of 1798, were 100,000 seamen and 20,000 marines; — the sum granted for the ordinary expenses of the navy, including half-pay to officers, was £689,858; and the sum voted for the extraordinary expenses of the navy, including those of building and repairing ships and other works, was £639,530. The aggregate of the various sums voted for carrying on the different parts of the naval service for the year, was £13,449,388.

During the eventful reign of George the Third, some most important improvements resulted from the wise and liberal views of the boards of admiralty, in countenancing eminent men, and engaging their talents in the service. Amongst these were general sir Samuel Bentham, and Mr. (now sir Isambert) Brunel. When the talents of such men were exercised with the freedom which was most compatible with the originality of their conceptions, and the vast resources of their minds, in the construction and arrangement of the most useful and complicated works, it was almost impossible that they should not lead to most valuable results. Such was particularly the case during the ten years which commenced in 1798, especially in the dockyard at Portsmouth. The introduction of machinery and steam power superseded the employment of the physical strength of men and horses in raising heavy weights, in pumping the docks, and in performing many important works in the establishment, in which they have since been constantly employed.

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* The *Endymion* was built on the lines of the French frigate *Pomone*, taken in the year 1794, with an increased breadth of about 8 inches; and her sailing qualities, and efficiency as a ship of war, have rarely been surpassed.

† James's Naval History, Vol. II., appendix.

General Bentham, to whom the service was much indebted for these improvements, was brought up to the profession of a shipwright, having entered as an apprentice in Woolwich dockyard in 1771. He finished his term of apprenticeship in the dockyard at Chatham; and, having remained a year and a half in the dockyards studying naval business, he went to the naval college at Portsmouth, and subsequently travelled in foreign countries, obtaining information on naval architecture. After this he served as a brigadier-general in the Russian service, and in 1791 obtained leave from that service to visit the principal manufactories in this country; he then obtained permission from the lords commissioners of the admiralty to visit the different dockyards.

He re-entered the service in April, 1795, and was made inspector-general of naval works, and a commissioner of the navy. Having made himself acquainted with the best methods of carrying on the duties at the various establishments he had visited, he soon recommended the introduction into the dockyards of a system of machinery for facilitating the performance of some of the most laborious works in those establishments. But at this time the substitution of machinery for manual labour was regarded with general distrust, lest it should interfere materially with established usages; and an apprehension prevailing that the artificers might rise in opposition to the use of machinery, from a fear that it would diminish the need of their skill and labour, the greatest caution and prudencewere necessary in carrying the measure against strong and general prejudice. This was, however, gradually overcome under the judicious policy of general Bentham, who chose to commence his course of improvements by the introduction of machinery on a small scale, rather than hazard the consequences of a general opposition to his plans on the part of the workmen, which he feared might be excited by any very bold innovation at the first step.

Amongst the earliest establishments of machinery was the erection of saw-mills in Portsmouth dockyard, which was performed under the able direction of general Bentham; and as he conducted his designs with great prudence, so he engaged to his assistance highly talented individuals,—and thus his best plans were accomplished in the most efficient manner. The saw-mills soon gave proof of their own value to the service; and a conviction of the essential excellence of machinery, which was produced by that work, constituted a good foundation for a just estimate of machinery in general. Hence other valuable works were subsequently erected; and at length steam power and machinery were regarded as taking rank with the other essential means of carrying on with efficiency the duties of the dock-yards.

Up to about this period, the use of machinery, to perform the heavy work in our dockyards, had not been attended to; for, notwithstanding the resources of the country, and the certainty that liberal inducements and encouragements offered by government would call into activity, and engage in inventive enterprise, minds fully adapted to supply the wants of the service with whatever contrivances and mechanical arrangements were required,—yet the private establishments of individuals were decidedly in advance of these.

The introduction of machinery marked an era in the history of the dockyards of England. But whilst the use of steam power and machinery had then, and has ever since continued to have, an important relation to the efficient performance of the duties in the dockyards, the value of machinery in those establishments remains to be fully developed in the maturity of a steam navy; so that, as with the progress of this, the value of the former rises, its present importance cannot be too strongly urged, that it may advance in efficiency in proportion to the magnitude and urgency of the duties which it may have to perform.

Although the board of admiralty, in accordance with the views of general Bentham, appeared determined to establish the use of machinery in the dockyards, yet there were various objections which it was desirable should be overcome by a reference to facts of experience, particularly with regard to the safety of the steam-engine. It was therefore proposed, by way of trial, to set up a steam-engine at Redbridge (a small yard, which general Bentham had used for the building of his vessels), for the purpose of working the machines which he had invented. This suggestion was not, however, carried into effect; but shortly afterwards, sometime in the year 1797, the steam-engine which had been prepared for Redbridge was set up in Portsmouth dockyard, and employed in working some new pumps for pumping the docks; but as the engine was required only occasionally for this purpose, other machinery was put up to be worked by the same engine.

As the quantity of machinery was increased, he formed and proposed a plan for improving the knowledge of practical mechanics, by the introduction of a regular establishment of millwrights into the dockyards; and in the course of carrying out the general design for improving these establishments, the metal-mills were erected about the year 1805. These were suited to the manufacture of all kinds of metal required in carrying on the works of the service, both cast and wrought; and the result of this was a great improvement in the quality of the metals most used in the naval service, with the advantage of an annual saving, which was at that time estimated at about £41,000. The improvement in the manufacture of copper, for the sheathing of ships, has been of great advantage to the service; and the importance of this branch of art has been so great, that metal-mills have lately been erected at Chatham.

But amongst the improvements in the dockyards, at the close of the last and the commencement of the present century, that which showed the most remarkable force of genius, was the invention and employment of the block machinery at Portsmouth: this has always been regarded and admired as one of the most refined and useful applications of mechanical art in the service. The model for this machinery was made by Mr. (since sir Isambert) Brunel; and on its being brought under the notice of the lords commissioners of the admiralty, it was referred to general Bentham. He at once saw the merit of the invention, and without hesitation recommended it to the government as a means by which blocks could be made with the greatest accuracy and uniformity; at the same time that the expense would be reduced in a very great degree. Upon this recommendation, Mr. Brunel's machinery was ordered to be constructed; it was therefore taken in hand in 1802, and completed in 1808; and Mr. Brunel received, as a compensation for his invention, £20,000; a sum which was then considered to be one year's saving, and an equivalent for his time and labour during the erection of the machinery.

The block machinery was, however, only a part of a system in which machinery superseded manual labour in the working of wood: this system included the wood-mills, in which articles of considerable variety were made, and in which sawing machinery was set up. A second engine has since been set up, to be employed in case of accident, and as auxiliary in the event of its being so required.

But the perfection of dockyards does not consist alone in the extent of their machinery, and other means for the performance of the various works by which the navy is kept up; a collateral and essential part of perfection consists in the extent and arrangements of their docks, building-slips, and basins, and the contiguity of the workshops, saw-pits, timber-sheds, and stores, to them. The want of basins and wet-docks was most severely felt in all our dockyards, for fitting out ships in the time of war; and the urgent necessity of such facilities for the repair and fitting out of ships would be much more felt with a steam navy, as it is always desirable to bring these vessels as near as possible to the factories, for fitting and repairing their machinery. And it must be an object of strong and growing interest with the nation, to contemplate the increasing energy with which those arrangements are being made and brought to completion. The metal-mills at Portsmouth, the lead-mills at Chatham, the introduction of machinery at the smitheries, the factories and basins at Woolwich, and the steam-basins at Portsmouth and Plymouth, with the other improvements at Chatham, are all contributing to the completeness of these arrangements, and rendering their important aid in facilitating the various operations in our naval arsenals.

It is intended to notice only a very few of the improvements which general sir Samuel Bentham introduced into the service. But amongst these may be mentioned the construction of caissons, or floating dams; and the first caisson that it was proposed to build in England was that at the entrance of the great basin in Portsmouth dockyard, in the year 1798, and which was completed in June, 1801. Caissons had been used for some years in foreign dockyards; but they were of a different construction, and were sunk by being charged with ballast. But those constructed by general Bentham have arched sides (*fig.* 1) meeting at the apex, (*fig.* 2) at the lower part.

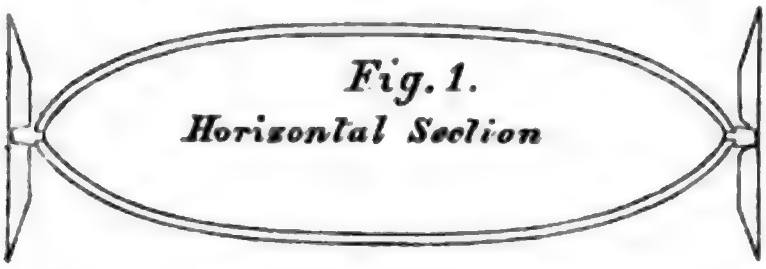
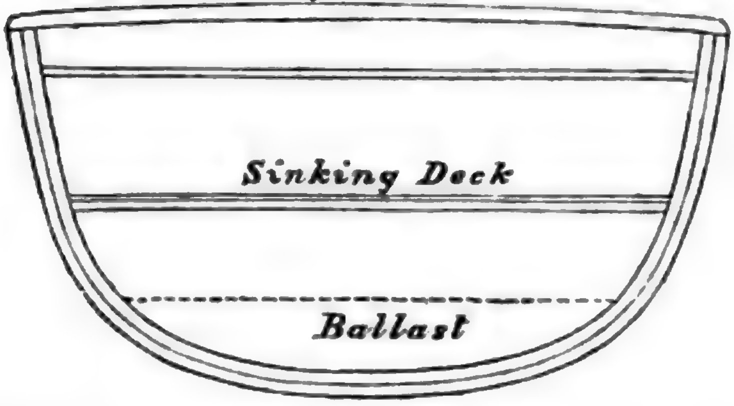


Fig. 1.
Horizontal Section

Vertical Longitudinal Section



Transverse Vertical Section

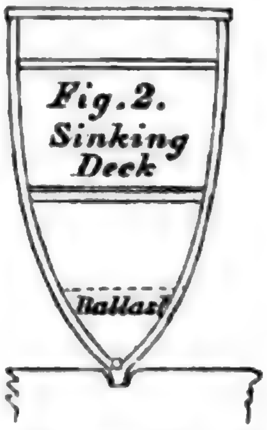


Fig. 2.

The stems and keel are formed to fit into a groove in the masonry of the piers, so that they shall be forced against the side of the groove by the direct lateral pressure on the opposite side, whether the greatest elevation of the water is on the outside, or in the basin or dock; and thus the passage of the water in either direction is prevented. The caisson is furnished with pumps and a penstock; and when it is intended to raise the caisson, the water is let out at low-water, and the penstock shut down, the water in the penstock below low water-mark is pumped out. When the caisson is required to be got into place again, it is brought into the groove, and sunk by raising the penstock to admit the water.

Considerable opposition was made to the building of this caisson, on the supposition that it would not answer the purpose for which it was intended; and on the day when it was first removed, a great assemblage of persons appeared anxious to witness the operation: amongst them were the principal authorities in that branch of the service, and many naval officers. Apprehensions were, however, removed by decided success; the vessel continued in constant use for nearly half a century, and has recently been replaced by a new one of the same construction, subject to some trivial deviation. This fact supplies a proof of the unreasonableness with which opposition to inventions is often urged; at the same time that it shows how safely the application of truly philosophical principles may be relied on. This invention, of which the suitableness to the end was so seriously doubted, has verified its own merits, and has been appreciated by the most scientific engineers of our own country, and applied to uses in which the circumstances are similar.

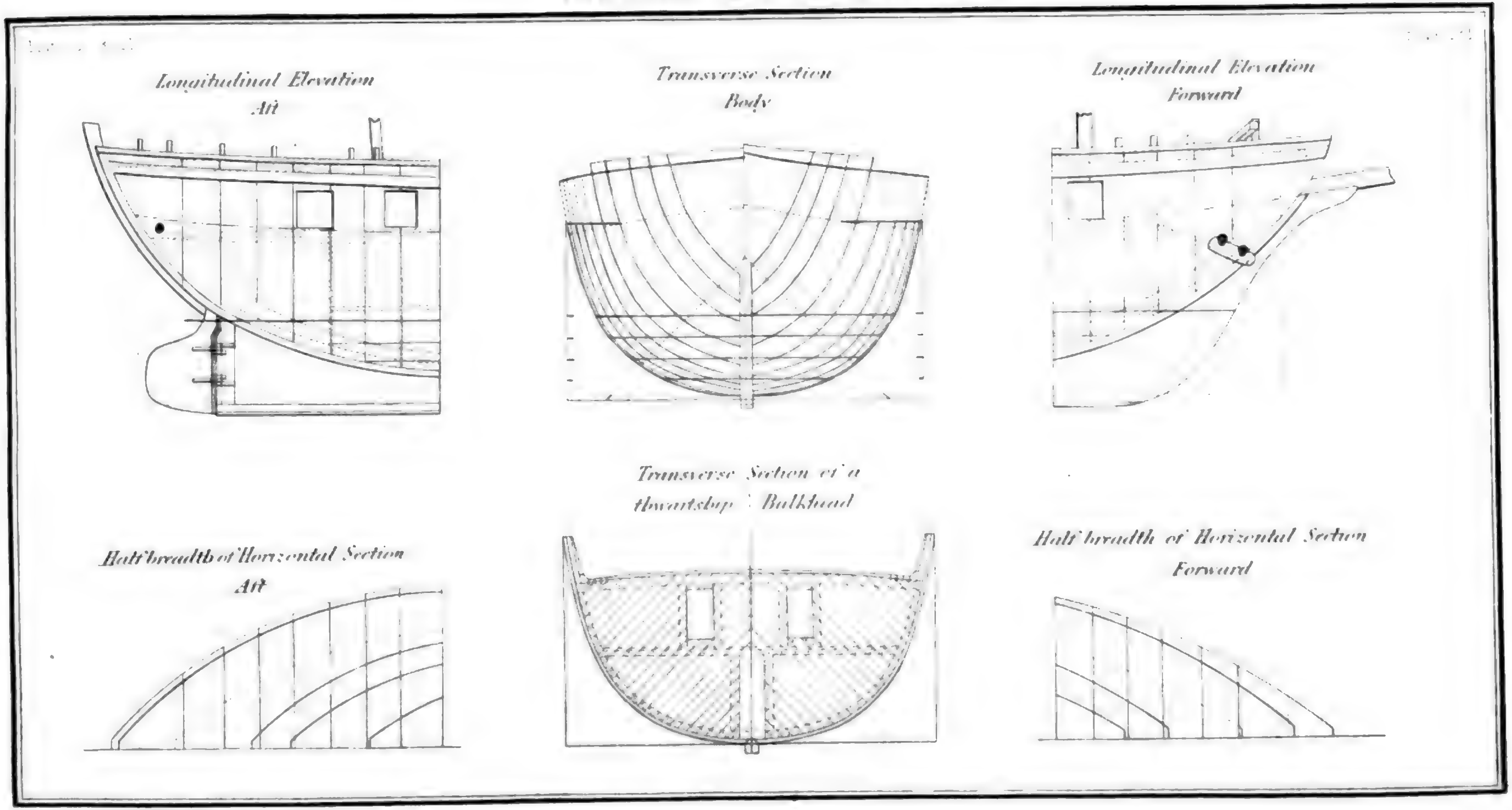
It was not only in carrying out great designs that general Bentham contributed to the improvement of the service; he invented many useful instruments and tools, for facilitating the operations of ship-building: amongst which are the coaking machines, and the treenail mooting machines; the latter of which have been of great advantage in giving to the treenails an accurately cylindrical form, and making them with great dispatch, whilst their value as fastenings of planks has been also much increased. The coaking of beams and masts of ships has added very greatly to the simplicity of their construction, at the same time that it has much diminished the labour and expense of making them.

General Bentham having overcome the prejudice against the use of machinery, had yet to encounter much opposition to the prosecution of his plans of improvement; for the construction of basins, docks, and jetties, was the object of strong objections, urged forcibly on the grounds of danger, the impracticability of execution, and the final inutility. Previously to these improvements being introduced, almost all the ships, on being fitted out, were obliged to have their equipment completed afloat in the harbour; whereas, by the use of deep docks, and basins, and jetties, ships may have their equipment completed to the extent of the draught of water, and can be then taken into the harbour. The advantages the service derived from the use of these means of fitting-out ships, consisted not only in the dispatch with which the duties could be performed, but also in a saving of expense, and the prevention of embezzlement; a contingency against which it was formerly very difficult adequately to guard. It was by the enlightened views, and persevering steadfastness to a purpose, which characterized general Bentham, that Portsmouth dockyard was placed so decidedly in advance of the others; and the same course of prudent policy, in carrying on improvements, is still raising those establishments to increased facilities of usefulness and efficiency.

General Bentham directed his attention likewise to ship-building, and endeavoured to introduce a new system, as it regards both the form of the body, and the forming and combination of the structure; and his views were carried out in building the *Dart* and *Arrow*, of 18 guns, and the *Netley*, *Milbroke*, *Redbridge*, and *Eling*, schooners, from the year 1796 to 1798, of the following dimensions:

	Dart.		Arrow.		Netley.		Milbroke.		Redbridge.		Eling.	
	Feet.	in.	Feet.	in.	Feet.	in.	Feet.	in.	Feet.	in.	Feet.	in.
Length on deck . . .	128	8	128	8	86	6	82	6	80	6	80	6
Length of the keel . .	—		—		71	0	67	6	64	6	64	6
Breadth extreme . .	33	10	33	10	21	8	21	6	21	6	21	6
„ moulded . .	33	0	33	0	—		—		—		—	
	to lower Deck.											
Depth in hold . . .	7	11	7	11	11	2	9	8	11	3	11	3
Draught of water afore	10	8	10	8	9	3	—		11	0	11	0
Draught of water abaft	11	8	11	8	—		—		—		—	

THE DART AND THE ARROW.



The peculiar form of body of these vessels is shown in *fig.* 1, *plate* 20; and the peculiarity of the various parts in the section is shown in *plate* 21. The decks were without sheer, and the beams were secured to the side by a thick water-way and binding strake, which were scored down on the beams, and bolted through the side; the whole acting in combination, similar to a plan practised by the French. But their transverse strength depended chiefly on the athwartship bulk-heads, and the braces which connected the two sides. The frames of these vessels were farther apart than usual, and of small scantling; whilst the outside plank of the bottom was thicker, and more so at the keel, and opposite to the main deck. The planking was chiefly of oak, except at the lower part, where it was of beech or elm; and there was but little inside planking. The vessels were built without knees, carlings, or ledges; and it was considered that by this mode of building, a saving would be effected of one-third of the materials, whilst a further great advantage would be gained by the use of smaller timber; such timber, being of young growth, might be obtained from trees which were felled to thin the plantations for the benefit of the trees which were to grow to maturity, would become seasoned in a shorter period, and be rendered therefore cheaper, and also more durable.

Under the lower-deck, amidship, in the *Dart* and *Arrow*, eight tanks were formed on each side in the body, each of which was to hold forty tons of water. They were lined with copper, tinned over; and it is stated that, after two years, the water was as clear and as sweet as it had been at the time of being put on board.

The magazines of these vessels were divided by partitions of copper, tinned over, for the purpose of safety; so that water might be let in without injuring the powder.

They had hawse-holes at each end, that they might ride in narrow channels.

They were armed with carronades, on the non-recoil principle; that is, that the guns should not recoil farther than the elasticity of the breechings would allow. This plan of fitting guns was adopted in large ships, with 18 and 32-pounders on the quarter-deck and forecastles, and to the main-deck of flush-decked ships; but it was not continued long in the service.*

The *Dart* and *Arrow* were rigged as ship-sloops, carrying somewhere about the quantity of canvas which was carried by the 300-ton ships then in the navy. They had taunt lower-masts, and square lower-yards, with small top-masts; and, to the main, a fidded royal-mast. The top-masts were alike, and several of the sails were of the same form and size, with the view to their being substituted for each other. Their tops were of a peculiar form, and well suited to give support to the top-masts. The *Pomone* and *Stag*, frigates, for sometime had tops of very similar construction; and, although they were continually cruising, they never carried away a top-mast whilst they had these tops.

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* In 1804 carronades were ordered to be fitted in all his Majesty's ships, on the non-recoil principle, under the immediate directions of brigadier-general Bentham.

In the construction of these vessels considerable genius and originality of conception were displayed, and there were in their peculiarities some points of decided merit. They were good sea-boats, and sailed remarkably well; and the last of these vessels which he built, the *Netley,* is said to have shown great superiority, especially in working to windward in blowing weather.

From an early to an advanced period of the year, England was kept constantly under the apprehension of some formidable attempt at the invasion of some part of her territories. And a perpetual watchfulness was maintained until a French squadron put to sea. Ireland, now the seat of civil disorder, had been already invaded by a small force of about 1000 men sent from France. And when, about the middle of September, a squadron was seen to put to sea, its destination was suspected, and its course watched to a considerable distance across the Atlantic. This vigilance induced the French commander, in order to elude the observation of his pursuers, to deviate materially from his proper course, and occasioned much loss of time. Hence, as information had been communicated of his movements, his appearance, when he returned, and made the coast of Ireland, was provided against, and his aim frustrated by a squadron of ships cruising on that coast. It was near the middle of October, when the enemy was seen approaching the north of Ireland; and sir John B. Warren, commanding the English squadron, ordered a general chase. The actions which ensued, brought into the hands of the English, the *Hoche* of 74, the *Loire* and *Immortalite* of 40, and the *Coquille, Embuscade, Bellona* and *Resolue* of 36 guns; leaving only two frigates and a schooner to return to France. But the prizes had been so resolutely defended, that several of them were reduced almost to the condition of wrecks before they were surrendered. The attempt at landing was made from only one frigate which had separated from her companions; but this attempt was quickly perceived to be of a desperate character; and the project of the invasion was necessarily abandoned.

But the naval event, which, in its character was sufficient to distinguish not only the year but the age, was the victory of the Nile. The French having made great preparations at Toulon, of the intention of which no intelligence was allowed to transpire, rear-admiral Nelson was sent to gain information as to the object contemplated in those preparations; but having been unable to gain any satisfactory account respecting the course the enemy's fleet had taken, he judged rightly from circumstances, and sailed directly to Alexandria in search of it: but there it had been neither seen nor heard of. Having returned to Syracuse without gaining any tidings of the French, Nelson returned up the Mediterranean, and on the 1st of August he arrived off Alexandria; but they were not there. He then sailed towards Aboukir, where he brought them to an engagement, and gained a complete victory over them—a victory to which he considered the term *conquest* more appropriate. The engagement resulted immediately, in the destruction of the *Orient* of a hundred and twenty guns, and a 36-gun frigate; and the capture of one ship of eighty guns, and seven 74-gun ships, and the sinking of another 36-gun frigate. The next day another of the enemy's 80-gun ships was taken possession of, and the *Timoleon* of seventy-four guns was destroyed by her crew to prevent the English from capturing her likewise. A naval victory of equal splendour had never before been gained by British arms: eleven, out of the thirteen line-of-battle-ships with which the French began the action, were either taken or destroyed, as well as two frigates;—leaving to the vanquished one ship of eighty guns, the *Guillaume Tell*, one of seventy-four, the *Genereux*, neither of which, as they were in the rear, had been engaged, and two 40-gun frigates, as the remnant of their fleet. These ships sailed out of the bay of Aboukir, on the 2nd; and to the great regret of Nelson, he had not the means of preventing their escape. A few frigates were then required, and the victory might have been perfect: Nelson's regret at this deficiency was equal to his conviction of their importance on such an occasion; but, whilst he lamented the escape of any of their ships, he had ample ground to exult, that the extraordinary victory he had gained, had deprived Buonaparte of the power of accomplishing any of the schemes he had formed in dependence upon his fleet. British India was confidently believed to be the next object of Buonaparte's attack: this victory must therefore have rendered India safe, at least for the time then present; and the disaster of his fleet could not soon be repaired.

Several of the prizes were afterwards known in the British navy by different names: the 74-gun ship *Peuple Souverain*, was retained at Gibraltar as a guard-ship, under the name of *Guerrier*, as it was thought unsafe to expose her to the contingency of rough weather in a voyage to England; the *Tonnant* and the *Conquerant* retained their original names; the *Franklin* was named *Canopus;* the ancient name of *Aboukir* was given to the *Aquilon,* in honour of the victory; and the *Spartiate* retained her original name. These four ships, the *Tonnant,** *Canopus, Spartiate,* and *Aboukir,* were nearly new; the last was rendered, for the most part, unserviceable, by the damages she received in the battle; the three others were still valuable ships in the British navy, built of superior timber, and not impaired by age. The *Canopus* was of the greater burthen of the two 80-gun ships by sixty-seven tons, although she was not so long on the gun-deck by 3 feet 8 inches. Her principal dimensions were: length on the gun-deck,

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* The *Tonnant* was rather the largest ship, being 194 feet 2 inches in length, 51 feet 9½ inches in breadth, and 2281 tons burthen; but the form of the *Canopus* was the most approved, and several 80-gun ships were built from her lines.

193 feet 10 inches; extreme breadth, 51 feet 6¾ inches; depth in the hold, 23 feet 4½ inches; burthen, 2,257 tons; and the length, therefore, 3·76 times the breadth. She was a very fine ship, and is still in the British navy.

During the year there were launched at the government dockyards two ships of the line, the *Temeraire* of ninety-eight guns, the *Foudroyant* of eighty guns,* the *Diomede* of fifty guns, and an armed transport; and at private yards there were launched for the royal navy, seven ships of seventy-four guns, viz.: the *Northumberland* of 1907, the *Renown* of 1899, the *Superb* of 1927, *L'Achille* of 1930, the *Ajax* of 1953, the *Kent* of 1964, and the *Dragon* of 1815 tons burthen;† a 36-gun and a 34-gun frigate; and two sloops of eighteen guns, and one of sixteen guns: and there were purchased six 18-gun sloops. There were obtained, also, by capture, eight ships of the line; besides those which were destroyed, as ordered by rear-admiral Nelson, after the battle of the Nile. On the other hand, the losses which the English navy had sustained within the same period were by no means trivial, although there had been captured from it only one ship of fifty guns, and a 32-gun frigate, above sloops and brigs, of which three were captured; whilst there were wrecked, foundered, and burnt, one ship of seventy-four guns, one of forty-four, two frigates of thirty-eight, two of thirty-six, two of thirty-two, and one of twenty-eight, and two 18-gun and two 16-gun sloops.

These events produced but little alteration in the state of the British navy. The aggregate amount of line-of-battle-ships had increased by two, including those which were upon the stocks, and those which were only ordered to be built. There were, however, in commission, at the beginning of 1799, about twelve or thirteen more ships of the line than there had been at the commencement of the preceding year, but this increase was almost entirely in the guard-ships of harbours, &c.; but the cruisers of inferior rates had increased by nearly twenty sail, and the entire number of ships and vessels composing the British navy had increased by twenty-six sail, and the aggregate burthen by 26,291 tons.

When copper sheathing was first applied to the bottoms of ships, it was soon found to be necessary to use some means for the protection of the iron fastenings in the bottoms, from the combined action of the salt water and the copper; and for this purpose the inside of the copper sheathing was coated. To improve this protection it was ordered, in January 1779, that tarred paper should be applied between the copper and the bottom; but when copper fastenings became used in ships' bottoms, it was considered that this means of preservation might be dispensed with, and it was therefore ordered in 1796 to be discontinued. In 1799, however, on the return of the *Caroline* frigate from a foreign station, and her being taken into dock at Woolwich, it was found that a treenail hole had been left open, but that leakage had been prevented by the tarred paper which had been put under the copper sheathing. The paper was therefore ordered to be again used, and the use of it has been continued ever since; except where felt, canvas, or some other substance has been occasionally used instead of it.

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* The *Foudroyant* was constructed by sir John Henslow, and was only 2062 tons burthen.

† These ships were a larger class of two-decked ships; the *Northumberland* after the *Imperieux*, the *Renown* was constructed by sir William Rule, the *Superb* similar to the *Pompee*, *L'Achille* similar to the *Leviathan*, the *Ajax* and the *Kent* as the *Triumph*, and the *Dragon* from the design of sir William Rule.

The supplies voted for the naval service of the year were a hundred and twenty thousand seamen and marines, £729,063 for the ordinary, and £693,750 for the extraordinary expenses of the navy; whilst the other sums voted for the maintenance of the seamen, &c., the wear and tear of ships, transport service, and other matters immediately connected with the naval establishment, raised the total to a sum exceeding £13,654,000.

The British fleets in the Channel, off Cadiz, at Gibraltar, and in the Mediterranean, accomplished but little against the enemy during the year. The French fleet quitted Brest, and passed the Straits of Gibraltar; the blockade of the Spanish fleet at Cadiz was then discontinued, that the ships engaged in that service might be employed more actively in the Mediterranean; and the Spanish fleet took immediate advantage of that alteration, got to sea, and entered the Mediterranean likewise. The efforts of the English fleets, now in that sea, were directed to the preventing of a junction of the French and Spanish fleets, but without success; and these, having united, repassed the Straits together, and arrived in safety at Brest, in the month of August, followed by a fleet under lord Keith, whose advanced ships arrived sufficiently near to discover the safe position of the enemy the day after they had arrived there. They remained quiet in that harbour during the remainder of the year, watched, but, of course, not interfered with by the English.

The expedition to Holland was the only other enterprise of magnitude that was engaged in by the navy during the remainder of the year, and the object of this was subordinate to military designs; but the result of it was highly important, as it related to the condition of the navy of that country. The expedition, for the conveyance of troops, left England under the command of vice-admiral Mitchell; but before it had arrived at its destination, admiral lord Duncan, who was commanding the fleet in the North Sea, joined, and took the command. His cruising had confined the navy of Holland to the ports of that country, and when the British fleet arrived, lord Duncan summoned admiral Story, commanding the squadron in the Texel, to surrender his ships for the service of the prince of Orange: to this message he replied, that the duty he owed to his country forbade his doing so, and that he should certainly defend it when it should be attacked. A dissatisfaction soon prevailed amongst the Dutch crews, and when the summons was repeated by admiral Mitchell a few days afterwards, most of the crews having mutinously refused to defend their ships, they came into the power of the English without fighting. But the inferior character of the ships thus obtained, rendered the acquisition of little value to the British navy, as few of the prizes were deemed by the English fit for cruisers; for hitherto the Dutch had given too little attention to the improvements which had been introduced into the navies of other European countries, by the increase of dimensions, which had raised their ships to a general and progressive superiority: an improvement of which the value became the more obvious as successive instances of it developed new advantages.

Several fine and valuable prizes were captured during the year. Amongst these may be mentioned the *Forte*, which was captured by the *Sibylle*, in the East Indies. This was a superior frigate of the largest class, measuring 170 feet on her gun-deck, 43 feet 3 inches in extreme breadth, and about 1,400 tons burthen; her length was, therefore, 3·93 times her breadth. The *Bordelais*, a French privateer, mounting twenty-four guns on a flush-deck, sixteen of them long brass 12-pounders, and the remainder brass 36-pounder carronades, was also captured. She was a remarkably fine new ship, of 625 tons burthen; her principal dimensions were 138 feet 6 inches long on the gun-deck, 31 feet 9 inches in extreme breadth, and 15 feet 1 inch deep in the hold, with a length 4·36 times her breadth. This construction rendered her an excellent cruiser; she was deemed one of the fastest sailing privateers from the French ports, and it was supposed that no British built ship would come up with her in a chase, provided there were a good wind. She was captured by the *Revolutionnaire*, a 38-gun frigate, which had been constructed by the same builder, and captured by the English in 1794; and this, it was said, was the only cruiser in the British service from which danger was apprehended by the French in a chase.

Upon the whole, the English captured from the French navy eight frigates during the year; and the *Leander*, of fifty guns, which had been taken from the English in 1798, was restored after the Turks and Russians had taken Corfu, where this ship was lying. Five Spanish 34-gun frigates had been captured within the same period, and twenty-four Dutch ships, viz.,—one of seventy-four guns, six of sixty-four, three of fifty, seven of forty-four, one of which was a frigate, one of forty, one of thirty-two, two of twenty-eight, and three of twenty-four, besides brigs, cutters, gun-vessels, &c.; but a material part of these prizes were deemed ineligible for the service of the British navy, and were not therefore purchased into it.

During the same year the British navy lost twenty-one ships and vessels; but only three out of this number were taken by the enemy, and these were a 10-gun brig of a hundred and twenty tons, a 6-gun schooner of seventy-one tons, and a small gun-vessel of eighty-seven tons. Of the rest, one foundered, sixteen were wrecked, and one was destroyed. The largest of these was the *Impregnable*, of ninety-eight guns, a ship that had been launched in 1786. The *Sceptre*, of sixty-four guns, which had been launched in 1781, was likewise wrecked; the others which were lost were frigates, sloops, brigs, and other small cruisers and armed transports; and ten of these had been formerly taken from the French, leaving the loss of *British* ships comparatively small.

Three 38 and two 36-gun frigates were the only ships launched during the year; one of the latter, the *Apollo,* in a private yard. The three 38-gun frigates, *Active, Hussar,* and *Amazon,* were nearly the same in dimensions and burthen; the greatest difference being twenty tons. The *Hussar,* which measured fifteen tons less than the first, and five more than the last, was 1043 tons; being 150 feet 3 inches long on the gun-deck, 39 feet 6 inches in extreme breadth, and 13 feet 9 inches deep in the hold; and the relative proportion of breadth to length was as 1:3·8. The differences in the principal dimensions were, that the *Active* and *Amazon* were each three inches less in the length on the gun-deck, and the former was four inches more, and the latter one inch less, in extreme breadth. The tonnage of these ships was about the same as that which sir Thomas Slade and sir John Williams had given to the 50-gun ships.

At the beginning of the year 1800 England had a hundred ships of the line, seventeen two-deckers not of the line, and three hundred and fifty-one frigates and inferior ships and vessels in commission as cruisers; a force varying in a very small proportion from that which had constituted the cruising navy of England at the commencement of the preceding year. At the same time there were twenty-four ships of the line, and eighteen under the line, chiefly frigates, either immediately under repair, or lying in harbour waiting to be repaired. Nineteen of these ships of the line, and a hundred and twenty-five of those under the line, were foreign built; and the entire amount of the British navy, including those which had been ordered to be built, and those which were unfinished, was one hundred and thirty-eight ships of the line, of 314,557 tons; three hundred and forty-one sail, from the flush-deck ship of fifty-six guns, down to the 14-gun brig-sloop, amounting to 224,755 tons; and two hundred and thirty-three ships and vessels of various descriptions, including fire-ships, gun-brigs, bombs, cutters, store-ships, prison-ships, armed transports, &c. There was, therefore, a difference of thirty-five ships and vessels in the whole; a diminution of one ship of the line; an increase of twelve ships, from those of fifty-six guns to the 14-gun sloop; and of twenty-four in the other descriptions of ships and vessels; and the increase in the aggregate burthen was 21,462 tons.

In February 1800, the supplies for the service of the navy were voted; when 120,000 seamen and marines were granted for the first two months, and for the remaining ten months the number was to be reduced by 10,000 men. The sum voted for the ordinary of the navy was £806,939, and that for the extraordinary expenses of the navy was £772,140.

The year opened with a proposal from Buonaparte as First Consul of

France to his majesty, for a restoration of peace; but the British government refused to entertain the overture.

Few naval events of general interest occurred during the year. The quietness of the French and Spanish fleet in Brest harbour, left the fleet in the channel to cruise without an enemy to encounter; and in the Mediterranean, the chief employment of the fleet was in the blockade of Malta. As it became apparent to the French that they would be ultimately obliged to capitulate, the preservation of some of their ships lying at that island was regarded as a matter of important consideration. The *Guillaume Tell,* a fine ship of 80 guns, was sent to sea in the most favourable circumstances for making her escape; but she was pursued, and captured after a singularly resolute defence. Her name was afterwards changed to the *Malta,* on being taken into the English service. The following were the principal dimensions of this ship: length on the gun-deck, 194 feet 4 inches; extreme breadth 51 feet 7¼ inches; depth in the hold, 23 feet 4 inches; burthen, 2265 tons; and the relative proportions of breadth and length, were as 1 : 3·76: one of the two frigates, in similarly attempting to escape, was also captured; and when the island of Malta was surrendered, the ships which were lying there, came into the hands of the English.

The prizes taken from the French during the year, were the *Guillaume Tell* of eighty guns, and the *Genereux* of seventy-four guns; two 60-gun ships, three frigates of forty guns; two of thirty-eight; two of thirty-six; and one of twenty-eight: besides smaller vessels and privateers; some of which were of considerable force; and two Spanish 34-gun frigates, which were also taken.

The English navy sustained in the same year, a considerable number of losses. The *Queen Charlotte* of 100 guns, was accidentally burnt on the coast of Italy; the *Marlborough* of seventy-four, and the *Repulse* of sixty-four guns, were wrecked on the coast of France; the rest were of inferior rates: and it is a remarkable fact, that the only two ships which fell into the enemy's hands, were a 20-gun ship, and a 14-gun brig-sloop,—their respective crews mutinying and carrying them into Brest and Malaga. Sixteen were lost accidentally, and six were lost by means of the enemy; nine of the whole, having previously come into the hands of the English as prizes.

Only two ships of the line were launched during the year; these were the *Spencer* and *Courageux** of seventy-four guns. The former of these, measuring 1917 tons, was built in a private yard; and the latter, measuring 1772 tons, at Deptford. The *Spencer* was 180 feet 10 inches long on the gun-deck,—being two inches less than the other; 49 feet feet 3 inches in extreme breadth,—being 2 feet 1½ inch more than the other; and 21 feet 10 inches deep in the hold,—being 2 feet more than the *Courageux*: and her length was 3·67 times her breadth. There were not more than four or five ships below the line launched. The largest of these was the *Leda* frigate of thirty-eight guns, and 1071 tons, measuring 150 feet 2 inches in length on the gun-deck; 40 feet 1 inch in extreme breadth; and 12 feet 9 inches deep in the hold: her length was 3·74 times her breadth. The others were 36-gun frigates; and as there were only one gun-brig sloop, and a small cutter purchased during the year, most of the increase which the British navy experienced, was realized by ships and vessels captured from the enemy.

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* The *Spencer* was constructed by Monsieur Barallier. The *Courageux* was not found to answer; her copper was raised considerably in Long Reach, river Thames, and owing to her being very uneasy, she had her poop taken off; as had also the *Plantagenet,* which was launched in 1801, being a similar ship.

But, as several of the prizes which fell into the hands of the English were not deemed fit to be taken into the service, or it was not considered, under existing circumstances, advisable to purchase them, the number of ships in the British navy, at the beginning of 1801, was very little greater, in the whole, than it had been twelve months previously. Seven ships of the line, and as many of inferior rates, were all the increase we find to have taken place.

In the year 1800 was formed the armed neutrality, a combination of Russia, Sweden, and Denmark, to prevent the searching of neutral ships by those of England for contraband of war. England insisted on her right to search; and resolved to break up the confederacy.

When, therefore, the supplies were voted for the year 1801, 120,000 seamen and marines were granted to serve in the navy, until the 26th of March; and from that time till the end of the year, the establishment was to be increased by 15,000 men. The sum voted for the ordinary expenses of the navy was £842,418; and that for the extraordinary expenses, as the building and repair of ships, and other works connected with this service, was £933,900. These sums, with those voted for the wear and tear of ships in commission; for transport service; for the half-pay of officers; and for the maintenance of prisoners of war, &c., exceeded in the aggregate, the sum of £16,577,000.

In order, then, to frustrate the designs contemplated by the armed neutrality, an expedition was planned, to be executed as soon as the advance of spring should render the navigation of the Baltic convenient. For this purpose, a fleet was assembled in Yarmouth Roads, consisting of fifteen ships of the line, and a considerable number of frigates, fire-ships, and other small vessels; and the command of it was given to admiral sir Hyde Parker, accompanied by vice-admiral lord Nelson, and rear-admiral Totty. On the 11th or 12th of March, the fleet put to sea, and proceeded to the Sound, having been joined by three other ships of the line; but, soon after leaving Yarmouth, admiral Totty's ship, the *Invincible*, of seventy-four guns, ran upon a sand-bank, and was lost.

An ineffectual attempt was made by negotiation, to detach Denmark from the confederacy; and the fleet then proceeded immediately to Copenhagen. The conduct of the attack was entrusted to lord Nelson, whose ability, as a naval commander and as a diplomatist, was fully displayed with consummate success. Great difficulties had to be surmounted in conducting the fleet into the channel leading to Copenhagen; and of the detachment of the fleet which was sent to execute this service, several ships grounded, and were unable to proceed. The rest of the ships were conducted up with great care on the morning of the 2nd of April; and as they respectively arrived at the positions assigned to them, they were anchored by the stern. The defence of the Danes consisted, according to Campbell's Naval History, of six sail of the line, eleven floating batteries, from twenty-six 24 pounders to eighteen 18 pounders, and one bomb ship, besides other vessels: these were supported by the Crown Islands, mounting eighty-eight cannon, and four sail of the line moored in the mouth of the harbour, and some batteries on the Isle of Amak.* James states, however, that there were no more than two ships of the line; those which had formerly borne that rank, but were now dismantled, though as efficiently armed, he considers not to have belonged to that class of ships.

The cannonade began at ten o'clock; and was maintained with great vigour on both sides for a long time, whilst the courage of the Danes rivalled that of the English; but at half-past one o'clock their fire slackened, and gradually diminished for sometime before it ceased. It did not, however, cease, until the negotiation, opened by lord Nelson, led to a statement of the requirements of Great Britain; and when these requirements were enforced by the communications of Nelson, the engagement was discontinued, by the surrender of the Danish ships,—allowance being made for the English to take possession of such as had already struck their colours. Four only of the Danish ships or floating batteries and vessels escaped the British; and one of these afterwards sank; but most of those which were taken possession of were found to be unserviceable, and were destroyed by the English before they left Copenhagen; and the only ship they brought away, was the *Holstein* of sixty-four guns: but, the victory thus obtained was dearly purchased, through the very steady and brave resistance of the Danes.

The consequence of this victory was, however, such as had been contemplated in sending out the fleet. The confederacy was broken; Russia soon expressed a wish for a continuance of friendly relations with England; and Sweden fell in with the object of the English, and an amicable intercourse was maintained between Great Britain and that kingdom.

England was soon again thrown into alarm by extensive preparations on the part of the French for an invasion. These preparations consisted, to a great extent, of boats for the conveyance of troops; and the assemblage of them at Boulogne was called a flotilla.

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* Campbell's Naval History, Vol. VII., p. 536.

Lord Nelson having returned from the Baltic, was appointed, in the summer, to command the squadron with which the destruction of the flotilla was to be attempted. He sailed from the Downs about the end of July, and early in August he made some vigorous attempts at destroying these boats; but they had been rendered so secure by the precautions of the French, and their defensive arrangements, that that great commander was obliged to desist, without having accomplished his object.

In the Mediterranean the employments of the British fleets were generally successful. The remnant of the French army in Egypt, having been obliged to capitulate, were conveyed to their own country; and the fleet, in the western parts of that sea, was engaged in harrassing both the French and Spanish fleets, and in frustrating their designs against the interests of England.

The prospect of peace was now unfolding; the restoration of that order of things appeared most necessary to the interests of Europe generally; and the preliminary articles of peace between England and France were signed at London, on the 1st of October; these were ratified, and the ratifications exchanged a few days afterwards; and, on the 12th of the same month, a proclamation was issued for the discontinuance of all hostile operations, and the definitive treaty was signed at Amiens, on the 27th of March, 1802.*

In the same work is given the following table, as a summary of French, Dutch, and Spanish ships lost, taken, and destroyed, from the commencement of the war in 1793 to October 1801:

	French.	Dutch.	Spanish.	Total.
Ships of the line .	45	25	11	81
Fifties . . .	2	1	0	3
Frigates . .	133	31	20	184
Sloops, &c. . .	161	32	55	248
			Total	516†

The result of the war to the navies of the belligerent powers during the last year of its continuance, may be stated to be, the loss to the French of one ship of seventy-four and one of sixty-four guns, one frigate of forty-four guns, two of forty, one of thirty-eight, four of thirty-six, and three of thirty-two; one of the last frigates having been formerly a British frigate, which had been captured in the early part of the year; leaving therefore the loss of *French* ships at twelve of different classes; all these, except one 36-gun frigate, were captured either by the English alone, or by them in connexion with the Turks, when their squadrons were united in the East.

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* Campbell's History, Vol. VII., p. 551. † Ibid, p. 552.

Spain lost two 112-gun ships, which were burnt whilst the English were in chase of them; a 34-gun frigate, which sank in consequence of the injury she had sustained at the same time; and a 30-gun xebec, which was captured by the *Speedy*, a 14-gun brig. The loss of England was severe: it amounted to three 74-gun ships; two of which were captured by the French, and the other was wrecked; a frigate of forty-four guns, one of thirty-six, and four of thirty-two; one 20-gun ship; three 18-gun ship-sloops; one 16 and one 14-gun brig-sloops; two gun-brigs; a 12-gun cutter; a bomb-vessel; a fire-ship; and a troop-ship. One of the 32-gun frigates was captured and afterwards retaken, as already mentioned; the 14-gun sloop, 12-gun brig, 12-gun cutter, the fire-ship, and the bomb-vessel, were captured by the French; the others foundered, were wrecked, or otherwise accidentally destroyed: the total loss, then, was twenty-one ships and vessels of all classes.

During the year no more than three ships of the line were launched; two 36-gun frigates, twenty 12-gun brigs, and two advice-boats were also launched; and a small number of ships below the line were purchased; but the aggregate numerical amount of the navy was but little altered by the changes which took place within the year.

When peace was restored, the naval establishment was considerably reduced; but confidence in the stability of this peace soon yielded to the fear of renewed hostilities, and the naval establishment was increased again before the end of 1802.

Whatever may have been the consequences of the war of the Revolution to the general interests of England, it was productive of some beneficial results in relation to her navy. To a great extent it had been a naval war; and in carrying on its operations, the English ships had been frequently brought into collision with ships of the enemy whose superiority could not be denied; a superiority which was the result of a greater regard to scientific principles in the construction of them. To a great extent the French ships were larger in relation to their force than the English ships, and hence there was introduced into the British navy a material alteration in the dimensions and burthen of the ships which composed it. This was particularly the case with the superior classes of frigates, which constituted a highly important part of the French as well as of the British navy. In addition to the greater dimensions and burthen, the French ships were commonly good sailers; and to that superior property the preservation of numbers had been owing when chased by English cruisers.

During the year 1802, the naval establishment was gradually reduced to a very great extent: in line-of-battle-ships, from a hundred and four, to thirty-two, and the number of cruisers below that rank was very much diminished; but the number of ships in ordinary was of course much increased, and the obvious result of so long and constant a service as that in which the fleets and cruisers of Great Britain had been employed, was an accumulation of old ships, to a great extent, if not wholly, unfit for further employment at sea. There were, accordingly, at the close of the war, many ships to be either converted into other classes, or removed from the establishment altogether, by sale, or by being broken up. Seventeen ships of the line were converted into other classes of ships during the year, and four were either sold or taken to pieces; the largest of these was the *Commerce de Marseille*; eleven, under the line, were converted into other classes; and a hundred and eleven were sold or broken up. In the same period, one ship of seventy-four guns, and two of fifty, were launched. These were the most material alterations that took place in the British navy during the year 1802.

The commencement of the year 1803, held out the prospect of renewed hostilities between England and France; but the circumstances relating to the possession of Malta, which rendered a new war highly probable, had not yet become so fully developed as to lead to any immediate preparation for the event. But it was not long before the prospect of war became more decisive; and from the number of 50,000 seamen and marines, that had been granted to serve in the navy, the number was increased, first to 60,000, and afterwards, in June, to 100,000 men. The sum voted for the ordinary expenses of the navy was £1,228,238, and that for the extraordinary expenses, as the building and repair of ships, &c., was £901,140; and the other sums granted for the naval service of the year, made up, with these, the total sum of £10,211,378.

Early in the spring, the British government appears to have determined on war; and on the 18th of May, a declaration of it was made against France. At this time France was taking active measures to prepare for the renewal of hostilities; an event which Buonaparte had been contemplating since the winter, but which he was not fully prepared for when it occurred.

When war was determined on, the ports and dockyards of England were rendered busy by the fitting out and repair of ships. Twenty-eight sail of the line had been put into commission by the end of May, besides a proportionate number of ships of inferior force. In addition to this, repairs were going on rapidly upon all classes of vessels; whilst it was seen to be desirable that the number of convenient cruisers should be increased; and orders were accordingly given for the building of one 38-gun frigate; fourteen large 16-gun ship-sloops; and six large 18-gun brig-sloops. Three 74-gun ships were likewise ordered to be built.

The day before the declaration of war was issued, a strong fleet, amounting, in ships of the line and frigates, to about a hundred sail, under the command of admiral Cornwallis, left England to cruise off the coast of France to watch the motions of the fleet lying at Brest: but the navy of France was yet unprepared to enter into the contest; it was distributed amongst a number of ports; and in that division, each part was too small to be formidable. The employment of the channel fleet consisted, therefore, principally, in watching the several ports in which the French ships were lying, so as to prevent a rendezvous of these ships in any port on the coast; and the year passed away without any memorable event resulting from the disposition of the fleet under admiral Cornwallis.

Immediately on the issue of the declaration of war, lord Nelson hoisted his flag on board of the *Victory* at Portsmouth, and proceeded to take the command of the small fleet in the Mediterranean. There he was employed in watching the fleet at Toulon; but as that fleet was not yet ready to be employed advantageously, it remained inactive in the harbour during the year, receiving such accessions as the constant building of new ships at that port could supply.

The British forces employed in the West Indies, were successful in seizing several islands belonging to the French and Dutch during the year; a 74-gun ship and four 40-gun frigates were also captured in the West Indies; and on other stations, the British cruisers captured or destroyed a small number of other cruisers from French ports.

During the year, the navy of England sustained the loss of twelve frigates and smaller vessels; two of which, the *Minerve* of thirty-eight guns, and a 12-gun schooner were captured by the French,—the former having accidentally run ashore upon the French coast; and an 18-gun sloop was captured by the Dutch at Curaçoa. All the others foundered or were wrecked; but only half of the entire number lost were British built vessels.

The number of men granted for the service of the navy for 1804, was the same as had constituted the establishment during the latter part of the preceding year. The sum voted for the ordinary expenses of the navy, was £1,020,670; and that for the extraordinary expenses was £948,520. The other sums granted at the time of voting the supplies, and subsequently during the year, made up a total, exceeding £12,040,600.

In the year 1775, it was ordered that with the view to expedite the building of ships, the work should be divided into articles or sections; and certain sums were allowed for the different parts of work, according to the rates of the ships: this was called task work; and in the year 1784, job-work for repairing ships was ordered to be introduced into the dockyards; but as it was strongly opposed by the workmen, it was not fully carried into effect until 1798, when the *Gibraltar*, at Plymouth, is said to have been the first ship repaired under this system.

Task and job-work, with a well-digested and equitable scheme to work from, and a judicious supervision, would be beneficial not only to the general interests of the service, by ensuring the requisite despatch in the execution of the work, but likewise to the workmen themselves, whose interests and exertions would thereby be essentially united. It is only by a bad system, in which too much detail is introduced into the scheme of prices for work, that task work is rendered objectionable, inasmuch as it offers an inducement to perform work unnecessarily, with a view only to augment the sum to be paid for the execution; whilst, if the work were paid for in the gross, there could be no inducement to destroy substantial work for the sake of having it to repair, as it has often been stated to have been done, but which an efficient supervision would effectually prevent.

It was at the renewal of the war in 1803, that the advantages of task and job-work began to be appreciated. For, a navy which had grown to a magnitude beyond precedent, required for keeping it in repair, exertion beyond what it had been previously necessary to make. The navy to be kept in repair, consisted of 177 ships of the line, and 593 ships of fifty-six guns and under; and in October 1805, there were in commission 124 ships of the line, including ships of fifty-four guns on two decks, 158 frigates, and 416 sloops and smaller vessels, including those which were hired.* During the period of this war, in which naval enterprise was carried on with the greatest vigour, the duties of the dockyards required the most persevering assiduity; and then the activity and energy of both officers and men were devoted, to the highest pitch of physical capability, to the arduous duties which devolved on them. Yet this constancy of labour, including every Sunday, could not keep pace with the pressure of duties which the employment of the navy imposed on the dockyards. It was in this condition of the public service, that the value of task and job work was the most fully ascertained; for it was only by the superior exertions which this system called forth that the navy was maintained in an efficient state, and rendered capable of achieving those triumphs which signalized the time.

At the beginning of the year 1804, there were in commission as cruisers, seventy-five ships of the line, and two hundred and eighty-one ships and vessels of inferior rates. There were also lying in ordinary for sea-service, forty ships of the line, and a small number of frigates, and inferior ships and vessels. Nine line-of-battle-ships, and eighteen under that rank, were in commission in harbour duty; and twenty-nine ships of the line, and thirty-nine below the line, were in ordinary.

As the season of 1804 advanced, an important duty of the channel fleet was, to watch the movements of the French along their coast; and especially in relation to the preparations which were in progress for the invasion of England. These consisted of gun-boats, flat-bottomed boats, &c., which had been accumulating ever since the preceding year. Great

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* Encyclopædia Metropolitana, Art. Naval Architecture, page 335; and according to the statement in the same work, the progressive increase was as follows: —

	1795	1797	1799	1801
Ships of the Line .	145	161	176	180
Of Fifty Guns and under .	454	530	627	684
Total . . .	599	691	803	864

numbers of these had been built along the coast, and up the rivers of France; and sent, as opportunities occurred, to the general rendezvous at Boulogne: and, notwithstanding the special attention which was paid to the movements relating to the invasion flotilla, as this assemblage of boats was called, great numbers of them were assembled at Boulogne; and the defensive arrangements were so well made, that they defeated the several attempts which were made to destroy them,—if not wholly, yet to such an extent, that the English were unable to do anything that materially affected the progress in the preparation of boats. These were the main objects of dependence; for though a fleet of ships of war was required in connection with these, yet that was merely as a protection to the fleet of boats. But no attempt was made during the year to employ these in the service for which they were designed.

Lord Nelson continued to command, in the Mediterranean, a fleet which was inefficiently prepared for any important service; and the general cautiousness of the fleet lying at Toulon, gave him little employment beyond that of blockading them there. Two very partial encounters served, however, to diversify his service on that station, without producing any material consequence. It was not, however, only the port of Toulon that claimed the attention of the British fleet. The doubtful character of Spain with regard to the war, rendered expedient, a strict watchfulness of the maritime movements of that country.

War was declared by that country against England in the course of the year. The direct cause of that measure was, that a squadron of English frigates had been sent out to intercept and seize four Spanish frigates loaded with specie and other valuable commodities, on their return from South America. One of these frigates was destroyed in the action, and the three others were captured, whilst no intimation of hostilities on the part of England had been previously given.

Few ships of force were captured during the year. The French prizes which fell into the hands of the English were mostly very light cruisers, privateers, or vessels engaged in commerce. Besides the treasure ships, there were two other frigates taken from Spain; and one was captured from the Dutch in the West Indies.

The British navy was considerably improved during the year, by the launching of new ships; only three of these were, however, of the line: the *Hibernia* of one hundred and ten guns and 2508 tons, and two ships of seventy-four guns. But besides these, there were launched for the service of the navy, one frigate of forty guns, one of thirty-eight, and four of thirty-two; four 18-gun, and seven 16-gun ship-sloops; thirteen 18-gun brig-sloops; forty-one 12-gun brigs; and twelve 4-gun cutters. On the other hand the navy sustained the loss of a considerable number of ships and vessels, which were wrecked and otherwise destroyed; and of five sloops and smaller vessels, which were captured by the enemy. Two ships of seventy-four guns foundered; one of sixty-four guns and one of fifty were wrecked; one 38-gun frigate foundered, and another was wrecked, as was also one of thirty-six guns; eight sloops and brigs, and one schooner, a troop-ship, and a receiving-ship, were wrecked; and a store-ship was burnt.

The increased energy in the management of the affairs of the navy, had improved the effective power of that establishment before the close of the year; and at the beginning of the year 1805, there were eighty-three ships of the line in commission as cruisers, and three hundred and ninety ships and vessels under the line. besides a small number of troop-ships, store-ships, advice-boats and tenders, and gun-vessels. There were, at the same time, thirty-three ships of the line, and sixty-one under the line, none of which were below a 16-gun ship-sloop, in ordinary, for further service at sea. There were also eleven ships of the line, and fifteen below the line, in commission in harbour service, and twenty-eight of the line, and forty-five below that rate, lying in ordinary. These ships, with those which were upon the stocks, and others that had been ordered to be built, made up a total of one hundred and eighty-one of the line, and five hundred and thirty-two below the line. This number did not include troop, store, hospital, and prison-ships, &c.

There were voted for the service of the navy in 1805, a hundred and twenty thousand seamen and marines, the sum of £1,394,940 for the ordinary expenses of the navy, and that for the extraordinary expenses was £1,553,690. The various other sums granted for carrying on the duties of the establishment made up, with these, a total amount of £15,035,630.

All this appeared to be required for the navy, in the circumstances of danger in which the country was placed; for as Spain had been provoked to declare war against England, there was the greatest reason to apprehend that the fleets of that country would be united with those of France in carrying on the war: and this was the case; for when the Spanish war broke out, it was the energy and decision of Buonaparte that subordinated the fleets of his ally to his own designs, and engaged their concurrence towards carrying into effect the plans which he had already formed. The great object which he hoped to be able to accomplish within the year was, the invasion of England by the means of his flotilla. The preparation of boats which constituted this force, had gone on increasing, until it was sufficient, according to his views, to convey across the Channel an army adequate to the great design of conquering England; but all this preparation was useless, unless, by some means, the fleet stationed in the Channel could be diverted from this object. This, then, was the point first to be aimed at. The means by which it was thought the Channel could be freed from any obstruction to this enterprise was, by sending the French fleets from Brest and Toulon to the West Indies, and beguiling the British fleets from the post of danger, with the view to act against those fleets in a distant part of the world. The general movements of the fleets were directed by Buonaparte, and the opportunity to employ the flotilla depended upon the successful performance of the plan which had been devised for the service of the fleets. That this plan would be frustrated was made nearly certain, almost as soon as any attempt was made to carry it into effect; for when the Brest fleet was seen endeavouring to get to sea, the British fleet, which was cruising at a convenient distance from the French port, perceived it, and an engagement was avoided by the French fleet returning into port.

The fleet lying at Toulon was to sail, to co-operate with the other French fleet, which had been ordered to proceed to the West Indies; and this fleet was watched by lord Nelson. In the attempt made by this fleet to leave the Mediterranean, several of the ships sustained so much injury by bad weather, that the whole of them returned to Toulon. Nelson was not, however, aware of this return; but, having lost sight of the enemy's fleet in hazy weather, he supposed they had gone with a favourable wind to Egypt, and proceeded up the Mediterranean in search of them; and as he returned from the east, he found the French fleet in the harbour of Toulon, still undergoing the repairs which had been rendered necessary in the unsuccessful attempt at leaving the Mediterranean.

A temporary absence of lord Nelson's fleet shortly afterwards, placed it in the power of the French admiral to put to sea; and, without any interruption, he succeeded in passing the straits of Gibraltar early in April, and anchored in the bay of Cadiz, where he was joined by several Spanish ships. With this reinforcement he left Spain, and arrived in the West Indies before the middle of May.

Lord Nelson sailed on the same route, as soon as he had been able to gain some intimation of the probable course which the enemy had taken; and he arrived in the West Indies early in June. The French soon gained information of his being there, and, without attempting to accomplish any of those great undertakings against the British colonies which had been contemplated, returned hastily to Europe; where they arrived without interruption, early in July, although admiral sir Robert Calder had been stationed with a fleet to intercept them. Nelson was unable to gain any certain intelligence of the object of his pursuit; but, concluding they would not remain in the West Indies when it was known he was there, he also returned to Europe, where he arrived a few days only after the French fleet had arrived, but of which he had not, however, been able to obtain any intelligence.

The French and Spanish fleet was tossed about by stormy weather for some time upon the coast of Spain, before it could enter a harbour. During this time the fleet under sir Robert Calder fell in with it, and brought it to a partial engagement on the 22nd of July. The dense state of the atmosphere prevented the English from conducting the engagement to a crisis;

and two Spanish line-of-battle-ships, the *San Raphaël* of eighty and the *Firme* of seventy-four guns, were the only prizes that were taken.

The fleet in the harbour of Brest was so closely watched during the summer, that although so much importance was attached to its being able to join the other fleet, and by that means to lead the British fleet clear of the channel, no opportunity was found of getting to sea; and this forced inactivity imposed on the emperor of France the necessity of leaving unemployed the invasion flotilla, to the contemplated use of which all the services of the fleets were deemed subservient.

As the combined fleet of France and Spain, which had recently returned from the West Indies, and had been engaged by sir Robert Calder, entered first the harbours of Ferrol and Corunna, and afterwards that of Cadiz, all the hopes which had been entertained by the French of the successful employment of the fleets were frustrated; and no prospect remained of being able, at least during the year, to land an army on the shores of England.

When it became known that the combined fleet had entered Cadiz, vice-admiral Collingwood took his station off the coast, to watch whatever movements might be made by that fleet. In this service he was reinforced by eighteen sail of the line under sir R. Calder, for whom no further service now remained on the northern coast of Spain. With a force so augmented, vice-admiral Collingwood held his station at a convenient distance from the coast, for gaining early information of any movement which the enemy might make.

On the 28th of September lord Nelson arrived, and took the command of the fleet, which now consisted of twenty-seven ships of the line, and a few frigates. He was, however, unwilling that this change should become known to the Spaniards; and, maintaining a line of communication with the coast by means of frigates and larger ships, he occupied a station considerably distant from the shore, with the view to keep the Spaniards ignorant of the number of his ships; for his object was not to blockade the fleet in the harbour of Cadiz, but to bring on, as soon as possible, a general engagement. In the meantime he hoped to be reinforced by a strong squadron of line-of-battle-ships, and he feared, also, that delay in being able to accomplish his designs, might bring to the enemy from Carthagena, Rochfort, or even from Brest, such reinforcement as would give them a more numerically important superiority, in the event of his not being so soon joined by the expected squadron.

Intelligence was communicated early in the month of October, that the combined fleet would put to sea so soon as the state of the wind and weather should be favourable for doing so. This was, however, sometime delayed; but, in order to be ready whenever the enemy should appear, a plan was drawn up by Nelson for conducting the engagement; but it was prepared upon the assumption of having his fleet increased to forty sail of the line, before carrying that plan into effect.

On the 19th of October a number of ships left the harbour of Cadiz; but, owing to the want of wind, the remainder of the fleet did not get to sea until the next day, when the two portions of the fleet united, amounting together to thirty-three ships of the line, and several frigates. Information of these important movements was communicated to the English, who were ready to secure all the advantage it should place within their power.

On the morning of the 21st the combined fleet, which had been first seen from the British fleet on the previous afternoon, was about seven miles to leeward; and Nelson readily determined to make use of these relative positions, by sailing down before the wind, and passing through the enemy's line. The quickness with which this might be done was deemed material, as that would prevent the enemy from retreating into the port which they had left. The British fleet was formed into two columns, led by lord Nelson and vice-admiral Collingwood; and the combined fleet was formed into a curved line, or rather two curved lines, the ships being irregularly arranged, and the whole fleet only a few leagues to windward of Cadiz.

It was a few minutes past noon when the great battle of Trafalgar was begun, by vice-admiral Collingwood; who, at the head of his line, engaged with very destructive effect a Spanish first-rate, and for some time his ship had to bear the whole fire from several of the enemy's ships. In the meantime Nelson was endeavouring to select for his antagonist the French vice-admiral; but no flag was seen from the *Victory* which would determine such a selection. As the *Victory* advanced towards the enemy's line, a most heavy fire was opened upon her; she, however, reserved hers until it would tell with effect, and in passing under the stern of the *Redoutable*, which happened to be the ship he was desirous of engaging, he poured into her so destructive a raking broadside, that nearly four hundred men were said to have been killed or wounded by it; and, at about twenty-five minutes past one o'clock, whilst the *Victory* was in close action with that ship, Nelson received a shot which had been fired from the mizen-top of the *Redoutable*. He fell, and was carried below, and died at the close of the engagement; but, though disabled and dying, he retained the command to the close, and took the strongest interest which the ebbing away of life would permit, in the progress of victory to its conclusion. Nine French, and eight Spanish ships of the line, surrendered to the English during the day; but, owing to the neglect in bringing the whole fleet and the prizes to anchor as soon as the battle was concluded, several of the prizes were driven ashore and wrecked. These were the *Bucentaure* of eighty, the *Fougueux*, the *Monarca*, the *Aigle*, and the *Berwick* (formerly English), of seventy-four guns. The *Redoutable*, of seventy-four guns, sank at the stern of the ship which had her in tow. The English ships had suffered so much in the loss of men, that they were unable to spare efficient prize crews. The *Algésiras*, one of the 74-gun ships which surrendered, had only fifty

Englishmen on board, although she had been dismasted. The unmangeable state of this ship on a lee-shore, in stormy weather, left to those who had charge of her no other prospect than that of perishing by shipwreck, unless the prisoners were released, to assist in rigging jury-masts and working the ship. The latter expedient was of course chosen; the prisoners were released; they resumed the command, and worked the ship into Cadiz; and then allowed the prize-crew to return to their own fleet. The *Santa-Anna* of one hundred and twelve guns, and the *Neptune* of eighty, both Spanish, were recaptured by a squadron that sailed from Cadiz. At the appearance of this squadron the British ships cast off their prizes, and formed into a line; but when the two ships had been recovered, the squadron returned with them into Cadiz.

In the hazardous condition of several other ships, in which the loss of them appeared to be the stronger probability, it was deemed the more prudent course to destroy them. These were the *Santissima Trinidad*, of one hundred and thirty guns, the *Argonauta* of eighty, the *San Augustin* and the *Intrepide* of seventy-four. The *Achille* was burnt before possession could be taken of her, after it had been signified that she had surrendered; and the Spanish ship *Rayo*, of one hundred guns, was captured three days after the battle; but this ship was afterwards driven ashore and wrecked.

Only one of the ships taken from the French was preserved and brought to England as a trophy of victory, and that was the *Swiftsure*, of seventy-four guns, formerly an English ship; and the Spanish 74-gun ships the *Bahama*, the *San Ildefonso*, and the *San Juan Nepomuceno*, were all that were saved to England out of the great loss that navy had sustained.

The French lost the *Indomptable* of eighty guns, which was wrecked near Cadiz three or four days after the battle. A further loss soon followed. Rear-admiral Dumanoir-le-Pelley, in the 80-gun ship *Formidable*, accompanied by the *Mont Blanc*, *Scipion*, and *Duguay Trouin*, of seventy-four guns, escaped from the battle of Trafalgar; and, hoping to be able to reach a French port in safety, he sailed for the western coast of France, rather than risk the meeting of an English squadron, by attempting to pass through the straits of Gibraltar. He was, however, fallen in with by a British frigate, which communicated the intelligence to sir Richard John Strachan, who was cruising with four ships of the line and two frigates. Chase was immediately given; but before the squadron could come up with that of the enemy, two British frigates, by a daring pursuit and annoying fire, retarded the flight of the French ships. When the British squadron came up with the objects of their pursuit, they were met with a courageous defence, which was maintained until all hope of success in further resistance had disappeared; when they successively surrendered, and were brought to England as prizes, and taken into the service of the British navy. The *Duguay Trouin* was built in 1798, and received the name of *Implacable* in the British service, and the *Scipion* was built in 1800: these were the only two of the prizes that served as cruisers. Their principal dimensions were as follow:

NAMES.	Length on gun-deck.		Extreme Breadth.		Depth in Hold.		Burthen in Tons.	Proportion of Breadth to Length.
	Feet.	in.	Feet.	in.	Feet.	in.		As
Scipion	182	6	48	8	20	4	1884	1:3.75
Implacable	181	0⅞	48	9⅛	20	7	1882	1:3.70

Several French frigates and large privateers were captured during the year by the British light cruisers: amongst the former of these were the *Didon* and *Ville-de-Milan* of forty guns.

The losses of the British navy were confined principally to the inferior rates of ships of war. The *Calcutta*, of fifty-four guns, was captured by a French squadron, and the *Sheerness*, of forty-four, was wrecked in the East Indies; one 36-gun frigate was captured, and another was wrecked; and several sloops, gun-brigs, and schooners, were also lost: making a total of twenty-six in number, of which nine fell into the hands of the enemy. But the *Arrow* sloop sank shortly after she had been taken possession of; her companion, the *Acheron*, was so much damaged that she was set on fire soon after she became a prize; and the *Cleopatre* was re-captured by the *Leander* a few days after she had been taken, at the same time that her captor, the *Ville-de-Milan*, was taken.

During the year the number of British cruisers was increased by seventy-eight sail, twenty-one of which were of the line; and at the commencement of the year 1806, five hundred and fifty-one ships and vessels were in commission as cruisers, one hundred and four of which were of the line.

Only three line-of-battle-ships were launched during the year 1805: these were the *Ocean* of ninety-eight guns, and the *Revenge* and *Fame* of seventy-four guns. The *Ocean* was of 2276 tons burthen: this was an increase in the tonnage in this class of ships, since the building of the *Glory* in 1788, of 332 tons; and the seventy-fours were similarly improved in dimensions and tonnage. There were also launched during the year six frigates, twenty-five sloops, twenty-five gun-brigs, and thirteen cutters; and at the beginning of the year 1806 there were, either in process of building or ordered to be built, twenty-six ships of the line, and a hundred and four ships and vessels of inferior rates: a fact which shows the estimation in which the efficiency of the navy was held, and the liberality with which the country enabled the admiralty to carry on the naval service, and to maintain that establishment in an efficient state; and the signal success of the navy had diffused throughout the British empire a more intense interest in that branch of power which had realized such great results, whilst the defeat of the French and Spanish combined fleets must have produced a corresponding depression in those countries, so far as the results of the war depended on their navies.

The naval services of the year 1806 were provided for by the grant of a hundred and twenty thousand men, including seamen and marines; the sum of £1,435,353 for the ordinary, and £1,980,830 for the extraordinary expenses of the navy; together with such other sums as amounted to a total of £18,864,341 sterling.

The employment of the British fleets during the year 1806 was not such, however, as was calculated to bring the war to a crisis; for although the French and Spanish nations retained such a naval power as would, in any joint operation, have been very formidable, yet the ships composing those navies were lying in so many ports, watched or blockaded by the English, that general co-operation was not in their power; but in the absence of the British blockading force, a strong division of the Brest fleet got to sea in the month of December, 1805. This division separated afterwards into two squadrons; one of which consisted of five ships of the line, two frigates, and a corvette, and was commanded by vice-admiral Leissegues. When it became known that this event had occurred, several squadrons were sent out in search of the enemy's squadrons. That under vice-admiral Leissegues was fallen in with and brought to an engagement by vice-admiral sir John T. Duckworth, having the command of a squadron of seven ships of the line. Three of the French ships were captured, and two others, to avoid a similar consequence, were run ashore, where they were destroyed. The other squadron consisted of six line-of-battle-ships, two frigates, and two corvettes, and was commanded by rear-admiral Willaumez. After cruising for some time in the Atlantic, he sailed to the West Indies: one of these ships returned thence, and arrived safe in Europe; the others, in endeavouring to carry into effect the designs which had been formed for annoying and distressing the English in their transatlantic possessions and commerce, were overtaken by a heavy gale of wind, which separated and disabled them, and one of them was driven ashore upon the coast of America, and destroyed; the others avoided falling into the power of a British squadron which was cruising in the West Indies. No other French squadrons of equal force to these became cruisers during the year, and only one other ship of the line, the *Marengo*, of seventy-four guns, was taken from the French during the same period.

The British light cruisers were very active; but the French were as cautious in avoiding them, where they could do so: and this careful avoidance of the English cruisers, by the French, led to great activity and enterprise in boat attacks along the coast.

Several of the French frigates which, during the year, became prizes to the English, were very fine ships: and most of them had a great relative length; for swiftness was a qualification of the first importance to the light cruisers in the French navy. The *Belle Poule* was five years old, 151 feet 6 inches long, 39 feet 11 inches wide, 1077 tons burthen, and her length was 3·79 times her breadth. The *Guerriere*, which was built in 1798, was 4 feet 3 inches longer, 2 inches narrower, and of 15 tons greater burthen than the *Belle Poule*; with a length 3·9 times her breadth. The *Alceste, Armide, Immortalité*, and *Gloire*, which were taken at the same time, were larger than most frigates of their rate, particularly the two latter. The *Immortalité* was 156 feet 6 inches in length, 40 feet 7 inches in breadth, 1157 tons burthen, and her length was 3·85 times her breadth; and the *Gloire* was 158 feet 2⅛ inches in length, 40 feet 7⅝ inches in breadth, 1153 tons burthen, and her length was 3·86 times her breadth. The *Presidente* was of nearly the same dimensions, with a burthen of 1148 tons.

The British navy lost, during the year, two ships of the line; one of which, the *Brave*, seventy-four, foundered; and the other, the *Athenien*, of sixty-four guns, was wrecked. The *Constance*, of twenty-two guns, was captured, and the *Heureux*, of the same force, foundered. All these ships, together with seven smaller vessels, out of the seventeen which were lost to the service, were foreign built.

The number of British cruisers in commission was increased during the year, by more than fifty sail. But the increase consisted entirely of ships below the line; and the line-of-battle cruisers had diminished in number by one in the course of the year.

At the commencement of 1807, there were 103 ships of the line, and 503 ships and vessels of inferior rates, in commission as cruisers; and at the same time there were twenty of the line, and thirty-one under the line, in ordinary for further service at sea. Thirty-six ships of the line, and seventy-one below the line, were in process of building or ordered to be built; four of these were of one hundred and twenty guns, two of one hundred, and three of ninety-eight. The increase in the navy during the year 1806, consisted chiefly in the new ships which were launched; only two of these were, however, of the line; there were three frigates, and all the rest were of inferior force. Twelve ships of the line, and forty of inferior rates, had been ordered in the course of the year to be built; five and twenty of these were 18-gun large brig sloops, averaging about 384 tons, built from the design of sir William Rule, as the *Cruiser*: their length was 100 feet on the deck, and 30·6 breadth extreme, and they were found a most useful class of vessel; they carried sixteen 32-pounder carronades, and two long 6-pounders.

The supplies voted for the naval service were, 120,000 seamen and marines for the first month, and an increase of 10,000 men for the remaining months. The sum granted for the ordinary expenses of the navy, was £1,557,934; and that for the extraordinary expenses, including the building and repair of ships, and the performance of other works connected with that branch of the service, was £2,134,904. The whole amount of the sums voted for the different branches of the naval service for the year, exceeded £17,400,000 sterling.

The invasion of Ireland was still a project by which Buonaparte contemplated the distressing of England; but it was considered, by the British government, that he would require aid from foreign navies to make the attempt at this invasion; and the expeditions which were undertaken in the course of the year to Constantinople and Copenhagen, were supposed to have been made with the view to cut off any hope of naval assistance from Turkey or Denmark, either for such a purpose, or for any other that might be similarly subversive of the interests of Great Britain.

England and Russia were in alliance; and it was apprehended that Turkey was so far under the influence of France, as to be induced to declare war against Russia; and that in that case, the Turkish fleet would be employed in subservience to the views of France.

Early in the year, a small squadron was sent, under the command of rear-admiral sir Thomas Louis, to reconnoitre the condition of the Dardanelles; and before this squadron returned, another was sent, under the command of sir John Thomas Duckworth, to force the passage of the Dardanelles, and to demand the surrender of the Turkish fleet to the English. In the event of their refusing to do that, he was to gain possession of it if he could; and if that should not be found practicable, he was to destroy it, or to cannonade the city of Constantinople.

On the 19th of February, the British squadron passed the Dardanelles, without sustaining much injury in the passage by the fire from those castles. A Turkish squadron, consisting of one ship of sixty-four guns, one frigate of forty, two of thirty-six, and one of thirty-two; two corvettes of twenty-two, one of eighteen, and two of ten guns; an armed brig, and two gun-boats;—lying a short distance beyond the castles, opened their fire upon the British ships, as soon as they had approached sufficiently near. Sir W. Sidney Smith was ordered by the admiral to remain, with three ships of the line and some frigates, to return this attack of the Turks. These had not long received the fire of the English, before they ran several of their ships ashore, where boats were sent to destroy them. A corvette and a gun-boat were captured; and all the rest of the Turkish squadron was destroyed. After this had been performed, an attack was made upon a strong battery, on which several guns were mounted, which threw very large stone balls: the place was stormed, and the works almost wholly destroyed. After this, the squadron proceeded towards Constantinople.

Beyond these parts of the service, it does not appear that the expedition to Constantinople was conducted with the vigour which was requisite to obtain the concessions that were demanded; and when these were refused, the British admiral failed either of enforcing them, or of gaining for himself the condition to depart without molestation. For, without having accomplished the object of the expedition, the British ships were got under weigh on the 1st of March to leave Constantinople, and, on the 3rd, they repassed the straits of the Dardanelles. But by this time the defences had been considerably improved, and the ships were fired upon by the cannon mounted upon these fortifications, some of which threw large stones of seven hundred weight, though from others the stones were not so heavy. Several of the ships were struck by these stones, which occasioned them considerable damage; but they all succeeded in passing the straits. One ship, however, was lost in the expedition,—the *Ajax*, of seventy-four guns, which was accidentally burnt.

The expedition to Copenhagen, in the summer of 1807, was planned with decision, and executed with skill and energy. The object of it was, to prevent the Danish fleet from becoming auxiliary to that of France; as there was ground to apprehend that might be the case, from the growing ascendency of Napoleon upon the continent. The demand that was then to be made was, therefore, the temporary surrender of the navy of Denmark to the British nation, on condition of its being restored at the restoration of peace. The demand was to be accompanied by such an armament as would be capable of giving effect to it, to the fullest extent; and admiral Gambier was entrusted with the charge of the expedition. On the 26th of July, a few days only after the order had been issued, the fleet sailed from Yarmouth. It consisted of one ship of ninety-eight guns, thirteen of seventy-four, and three of sixty-four; together with a proportionate number of frigates, sloops, and lighter vessels. This fleet was afterwards reinforced by four seventy-four and three sixty-four gun ships, and a considerable number of frigates, sloops, &c.; making forty sail under the line, and to these were added nearly 400 transports.

When the British fleet arrived, early in August, and the demand was made for the conditional surrender of the Danish navy, it was of course rejected; and the Danes proceeded to improve the defences of the city. The English advanced, and landed their troops, who occupied several days in constructing the works, to act both against the Danish gun-boats, and the city of Copenhagen. On the 17th, the admiral advanced, with a strong division of his fleet, into Copenhagen-road. Some further time was occupied in completing the preparations that were in progress; and, on the 1st of September, the British commander-in-chief summoned the Danish commander to surrender the fleet upon the conditions of trust which had been before mentioned. This was refused: and the city was cannonaded and bombarded, with some intervals of intermission, until the city was extensively damaged, and there appeared to be no hope in opposing any farther the demands of the English,—who would entertain no negotiations in which the surrender of the Danish fleet was not admitted; when the terms of capitulation required by the English were yielded to, and the capitulation was signed on the 7th of September. The English, according to the terms of surrender, immediately entered into possession of the citadel and the arsenal, and began to repair and fit out the Danish ships, all of which had been surrendered to them.

These were three ships of eighty guns, twelve of seventy-four, two of sixty-four; two frigates of thirty-eight, and six of thirty-six guns; and one 32-gun frigate, in attempting to escape when the English were approaching Copenhagen, was pursued and captured by a British twenty-two gun ship. Out of these seventeen ships, fourteen were, in less than a fortnight, removed from the arsenal; and the remainder, with the frigates, were got ready within six weeks, the time which had been stipulated for the English to hold possession of the arsenal. Three seventy-four gun ships were on the stocks when the city was surrendered; the frames of two of these were taken to pieces and brought away; and the other ship, being in a more advanced state, was sawn, and rendered incapable of being completed. A few old ships, which were considered to be not worth bringing away, were destroyed;—leaving sixteen sail of the line to the captors, besides inferior ships, gun-boats, &c.

On the 21st of October, the British fleet and prizes quitted Copenhagen-road; and in the course of their passage out of the Sound, one of the Danish eighty-gun ships ran ashore, and was destroyed, as she could not be got off; and in the rough weather which occurred during the passage of the fleet to England, almost all the gun-boats were destroyed. The rest of the prizes reached Yarmouth and the Downs in safety.

But few of the prizes were, however, of much value to the English. The *Christian* 7th of eighty guns, the *Norge, Dannemark,* and *Princesse Carolina* of seventy-four, and the *Syeren* of sixty-four, were the only line-of-battle-ships that were afterwards fitted out as cruisers. The first of these, which had been built in 1804, was indeed considered a very fine ship in every respect; but her dimensions were not large for the armament she bore. She was 187 feet long on the gun-deck, 50 feet 10½ inches in extreme breadth, and 20 feet 10 inches deep in the hold, and she measured 2131 tons.

From the high estimation in which this ship was held, the *Cambridge* was ordered to be built precisely similar to her; and in the general dimensions there was scarcely a material variation, except that the *Cambridge* measured six tons less than her admired exemplar. On the reduced lines of this ship, the *Hawke, Black Prince, Melville,* and *Wellesley,* were built, with a length on the gun-deck of 176 feet 1 inch, and breadth extreme 47 feet 8 inches; the lines of these ships assimilated to the lines of the great Swedish constructor, Chapman. Immense quantities of naval stores, consisting of timber, masts, yards, canvas, rope, and other materials, were taken from the arsenal at Copenhagen, and brought to England, constituting a full cargo for ninety-two transports.

Early in the winter of 1807, a fleet of nine ships of the line was sent, under the command of sir Sidney Smith, to blockade the Tagus. This course had been rendered necessary by the relations of France and Portugal. The prince-regent of the latter country had been induced, under an apprehension of the invasion of his country by a French army, to comply with the requirement to exclude from the ports of Portugal all English ships, both naval and mercantile. The inconvenience that must have resulted from such exclusion was sufficiently evident to prompt the government to take a very decided course, with the view to restore the good understanding which had existed between this country and Portugal. Information of the new state of affairs in that country reached England early in November, and the fleet was sent out without delay; and when it arrived off the Tagus, the blockade was immediately commenced, and the British ambassador retired on board of the fleet. The blockade was maintained with so much strictness, as to render the continuance of it very inconvenient; and a flag of truce was sent with a proposal of terms for raising the blockade. The conditions were, that the Portuguese fleet should be surrendered to England, or that the prince-regent should retire with it to his dominions in South America. The latter alternative was accepted; and as almost all the ships constituting that navy were in a condition to put to sea, the prince-regent and the court of Portugal embarked; and the fleet was escorted a part of the way by the whole, and the remainder of the voyage by a part, of sir Sidney Smith's fleet.

In the meantime a French army entered Lisbon, and a Russian squadron the Tagus, where it became blockaded by sir Sidney Smith; who had not, however, been long in conducting this duty, before he learnt, on being reinforced by a squadron from England, the hostile conduct of Russia. This had been suspected, and the information being now certain, the blockade of the Russian ships was continued during the remainder of the year.

The light cruisers of the British navy were very active during the year, whenever there were suitable objects of enterprise. In the West Indies captain Brisbane, in the command of a squadron of four frigates, was sent by the commander-in-chief to ascertain the bias of the inhabitants of the Dutch colony of Curaçoa, before any attempt should be made towards reducing the island; but as the possession of the island was the ultimate object in contemplation, captain Brisbane considered the more certain way to attain this object would be, to make a bold and vigorous attack before the apprehensions of the inhabitants had been excited. Immediately on his arrival he, therefore, brought the whole of his little force to act with the best effect against the island; and the inhabitants, being taken by surprise, were unprepared to offer any effectual resistance: the consequence of which was, that long before the close of the day the island, together with a frigate which was lying there, was placed by capitulation in the possession of the English. This event occurred early in the year; and, towards the close of the year, the Danish West India Islands of St. Thomas and Santa-Croix capitulated, and fell into the hands of the English.

In the early part of the year Monte Video was attacked by a squadron, accompanied by a considerable body of troops; and after the French army had gained possession of Portugal, a British squadron came to an anchor at the island of Madeira, and a summons was sent to the governor to surrender to Great Britain: as no opposition was made to it, the island came quietly into the possession of the English.

From a state, as it appears, of ample efficiency, the cruising fleets of England rose, in the course of the year, to a height of numerical strength beyond what they had previously reached. Within this period ten line-of-battle-ships were added to the number of commissioned cruisers. This increase consisted almost wholly of ships of seventy-four guns; the several classes of these ships had been increased by fifteen, and now amounted to seventy-six sail. Two more 80-gun ships had been commissioned as cruisers; but the number of 98-gun ships had been diminished by six; and the 64-gun ships, by one. This alteration in the character of the cruisers, in bringing into service a larger proportion of the most active class of line-of-battle-ships, appears to have been a material improvement in the arrangements of the British fleets, viewed in connection with the relative condition of other European navies, shut up, as they were, for the most part, in the several ports of the countries to which they belonged, and affording little prospect that they would, for a considerable time to come, place it in the power of a British fleet to bring on another general engagement; but for the little prospect there was of such an event, it might have been desirable to increase the number of heavier ships. The under-line cruisers continued with little variation, and an increase of only two ships.

Two 74-gun ships of the largest class (the *Bulwark* of 1940, and the *Warspite* of 1890 tons,) were launched during the year; as were also seven other seventy-fours, that had been built in private yards: the *Aboukir, Cumberland, Elizabeth, Marlborough, Sultan, Valiant,* and *York,* with an aggregate burthen of 12,111 tons, being on an average 1730 tons to each. There were about forty ships and vessels below the line also launched during the year. Five of these were 38-gun frigates, of which the largest was 1090 tons burthen; and the average of the whole was 1080 tons. Two 32-gun frigates and several 22-gun ships, thirteen 18-gun ship-sloops, sixteen 18-gun brig-sloops, and one 12-gun brig, were also launched. The whole of these were built in private yards.

The total amount of the British navy at the beginning of 1808 was one hundred and eighty-nine ships of the line, and six hundred and fifty-three below the line, in commission and in ordinary. Twenty-nine line-of-battle-ships, and thirty-three of inferior rates, were in the course of building, and nineteen 74-gun ships, and thirty-three brig-sloops, were ordered, in the course of the year 1807, to be built.

The losses of the British navy were, on the other hand, very considerable in the same period. Besides the *Ajax*, which was accidentally burnt in the expedition to the Bosphorus, the English lost a 74-gun ship, the *Blenheim*, which foundered in the Indian Ocean. Three frigates were wrecked, and one foundered; two 22-gun ships were wrecked; five sloops were wrecked, one foundered, and one was captured; four gun-brigs were wrecked, one foundered, and two were captured; four cutters were wrecked, four foundered, and six were captured; one bomb-vessel was wrecked, and one foundered; and one fire-vessel was wrecked: making a total loss, during the year, of thirty-nine sail.

The naval service of 1808 was provided for by the grant of a hundred and thirty thousand seamen and marines to be employed during the year; and by sums of money suited to the carrying on of the operations of the war by sea. The sum granted for the ordinary expenses, including half-pay to naval and marine officers, was £1,142,960; and the sum for the extraordinary expenses, which included those incurred in the building and repair of ships, was £2,351,188. The other sums voted for the different purposes of the naval service amounted, with these, to a total, exceeding £18,087,500.

Material changes had recently taken place, whilst others were waiting to develop themselves, in the relations sustained by some of the most powerful nations of Europe; which, notwithstanding the depression to which the two principal hostile navies had been recently reduced, involved the necessity of maintaining the British navy in a condition capable of meeting the fleets which might be fitted out in the Baltic, as well as in the more southern parts of Europe. Russia had been brought under the influence of Buonaparte; and the declaration of war which that country issued against England, was received and replied to in December 1807.

The breaking out of this war with Russia rendered it necessary to send a fleet into the Baltic. Sweden, alike with England, became involved in the war with Russia. When, therefore, in the beginning of the summer of 1808, the British government sent sir James Saumarez into the Baltic with a fleet consisting of the *Victory* of one hundred guns, eight ships of seventy-four guns, and two of sixty-four; accompanied by several frigates, sloops, gun-brigs, and a large fleet of transports for the conveyance of the troops, they had a joint object in contemplation in connection with Sweden, for whose assistance troops were sent out; and when, in the course of the summer, a Russian fleet presented itself, the Swedish fleet, accompanied by two or three British line-of-battle-ships, chased it until it retired into port. The English ships, however, being better sailers than their companions, succeeded in coming up with one of the enemy's ships that had been separated, engaged her, and compelled her to strike. But the nearness of the Russian fleet prevented them from taking possession of their prize; and when the fleet retreated into port, this ship followed as near to the place of safety as she could. Assistance was then sent out with the view to conduct her into port; but this was prevented by the interference of the English, who, being finally unable to secure the ship as a prize, destroyed her.

Sir James Saumarez having joined the combined English and Swedish fleet, which, from the time that the Russian fleet had retired into port, had been blockading that port, arrangements were made for destroying the whole of the Russian fleet, lying in the harbour of Rogerswick, by means of fire-ships; but the design was rendered impracticable by means of a strong boom which had been placed across the entrance of the harbour. Soon after this, the blockading fleet retired from before the port; and the Russian admiral took an early opportunity of sailing likewise, and arrived in safety at Cronstadt.

After the great disaster which the navy of France had sustained at Trafalgar, vigorous efforts were made, under the orders of Buonaparte, to add to it such a number of powerful new ships as would restore it to the state of importance from which it had declined. The necessity for this individual national regard to the navy, was now increased by the separation of Spain from the interests of France; for the naval adjuncts which might have been obtained by other alliances, could not be so formidable as that of Spain had been. In the spring of this year, the French navy included more than sixty ships of the line; and these were to be increased by twenty others, which had been recently ordered to be built at several ports in France and the Netherlands.

The Russian squadron in the Tagus was continued under a strict blockade; but the English lost the object of their blockade at Rochefort. The squadron under rear-admiral sir Richard J. Strachan was obliged to retire from before the port to obtain supplies; and as he was unable for several weeks to renew the blockade, admiral Ganteaume sailed, with six ships of the line, a frigate and a corvette; and with the exception of one ship that was injured in the rough weather which then prevailed, and was, in consequence, sent back into port, his squadron arrived in safety at Toulon. Here he increased his force, and put to sea again with ten ships of the line, five frigates and corvettes, and several armed transports. The immediate object of this movement appears to have been the relief of Corfu, which was effected without any interruption.

Vice-admiral lord Collingwood held the command in the Mediterranean, and was cruising with his fleet, when the fact became known to some detached cruisers, that the French fleet was at sea; and the information was communicated to the commander-in-chief, who cruised in search of the enemy's fleet until sometime after it had returned in safety to Toulon-road, more than two months after their departure early in February.

The restoration of peace between England and Spain obviated, only partially, the necessity for the employing of British cruisers along the shores of the latter country; for the presence of the French light cruisers upon the coast and in the harbours of Spain, was a continual annoyance to the Spaniards, as well as to the English. England had been applied to for aid against the French; and that aid was readily afforded. This change in the views and relations of Spain did not, however, take place until the summer: but previously to the restoration of peace between England and Spain, two Spanish ships from South America, laden with valuable cargoes, were captured by two light cruisers.

With the exception of the sailing of the Rochefort squadron to Toulon, and the little expedition of a fleet from that port, the French maintained a general cautiousness in the employment of their fleets and squadrons. The French cruisers which were fallen in with, were generally of the small classes of vessels. But, in several of the encounters that took place between these and the English cruisers which met them, the latter were decidedly inferior; and owing to the disparity in the capabilities of the ships, a small number of British cruisers were obliged to surrender. There were several ships lost to the British navy besides the few that became prizes to the French cruisers, and the Danish gun-boats upon their coasts. The *Jupiter* of fifty, the *Leda* frigate of thirty-eight, the *Crescent*, *Flora*, and *Meleager*, of thirty-six, and the *Astrea* of thirty-two guns, the *Banterer* of twenty-two, the *Muros* of twenty, and the *Bermuda* of eighteen guns, were wrecked. Four 16-gun brig-sloops, one 14-gun brig, two 12-gun brigs, one cutter of twelve guns, one of ten, and four of eight, were also wrecked; and one 8-gun cutter foundered. One 12-gun brig was destroyed by the enemy's batteries whilst engaged in cutting out; and a 10-gun brig was also destroyed after having been run ashore to avoid being captured.

The prizes which were made during the year were few, and of small importance, as it respects the British navy. Two 74-gun ships, the Danish *Prindts-Christian-Frederic*, and the Russian *Sewolod*, were the only ships of the line that were taken. There were five frigates captured; one of these was the *Badere Zaffer* of forty-four guns, taken from the Turks. She was constructed after the French style, and although she was a very handsome frigate, she was neither well built, nor sufficiently strong, and therefore not deemed suitable to be taken into the service. The Dutch 36-gun frigate *Guelderland*, after having been taken by the *Virginie*, served for some time as a British cruiser. Two French 40-gun frigates, the *Piémontaise* and the *Thetis*, were taken during the year; and the *Artémese*, of the same class, was chased by the English, run ashore near Brest, and destroyed. Only three frigates were, therefore, transferred within the year from foreign navies to that of England.

There was a large number of ships, sloops, &c., launched during the year 1808; at the head of these was the *Caledonia*, a first-rate of one hundred and twenty guns. This ship was ordered to be laid down, in 1794; but the building of her was not commenced until 1805. She was larger than any other ship that had been built in England, nor had any ship, with the exception of the *Commerce de Marseilles* (which was surrendered to the English at Toulon in 1793) equal to this, fallen into the possession of the English; but this ship exceeded the *Caledonia*, as will be best seen by placing the principal dimensions by each other:

NAMES.	LENGTH.				Extreme Breadth.		Depth in Hold.		Burthen in Tons.	Proportion of Breadth to Length.
	On the Gun-deck.		Of Keel for Tonnage.							
	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.		As
Commerce de Marseilles . .	208	4	172	$0\frac{1}{3}$	54	$9\frac{1}{2}$	25	$0\frac{1}{2}$	2747	1 : 3·802
Caledonia.	205	0	170	$9\frac{1}{5}$	53	8	23	2	2616	1 : 3·82

There were five 74-gun ships—the *Blake, Bombay, Invincible, Venerable,* and *Victorious,*—launched, and nearly seventy frigates and sloops; fourteen of these were large 18-gun brig-sloops, and more than thirty were 10-gun brig-sloops.

The vessels of this latter class were good sea boats, although they were not fast sailers; but the dulness of their sailing is sufficiently accounted for, by the armament and other weights which were put on board of them being too great, in relation to the power of sail which their dimensions would allow them to carry. To have given scope for the production of excellence in these vessels, when their armament had been determined on, larger dimensions should have been given to them; but as the armament of these brigs was of too small a caliber to furnish them with sufficient power against the enemy, they might, with sufficient dimensions, have been armed with 24 instead of 18-pounder carronades; and dimensions suited to this description of armament, would have enabled them to carry such a quantity of sail as would have rendered them a far superior class of vessels to what they ever were. They were constructed by sir Henry Peake, with a tonnage varying generally between 235 and 240 tons, and with dimensions of about 90 feet in length on the gun-deck, 24 feet 6 inches in extreme breadth, and 11 feet depth in the hold.

Six 74-gun ships; eight large 38-gun, and six small 36-gun frigates; twelve 18, five 14, and eight 10-gun brig-sloops; and six 10-gun cutters, were ordered, in the year 1808, to be built. Some of these were launched; and at the close of the year there was a large number of line-of-battle-ships upon the stocks, principally of the middling class of 74-gun ships.

At the beginning of the year 1809 there were a hundred and thirteen ships of the line in commission as cruisers; the same number as there had been at the commencement of the preceding year; but the under-line cruisers had been increased since that period by more than sixty sail, and amounted now to five hundred and seventy-one ships and vessels, from the

56-gun flush-decked ships to the 4-gun cutters. A hundred and twenty-nine of these were frigates; nineteen others were post-ships; fifty 18-gun ship-sloops, and seventy 18-gun brig-sloops; twenty-eight 16-gun ship-sloops, and forty-seven 16-gun brig-sloops; there were thirty-three 10-gun brig-sloops, and seventy-six 12-gun brigs, besides a small number of other classes, and more than seventy cutters. There were also fourteen ships of the line, and thirty of inferior rates, in ordinary, for further service at sea. Never before had England displayed such a naval force as this.

The supplies granted for the naval service of the year 1809 were a hundred and thirty thousand seamen and marines, and the sum of £8,112,000 for their maintenance: this was at the rate of £4 16s. a man per month, being an increase of one guinea to each man for that time. The sum voted for the ordinary expenses of the navy, including half-pay to naval and marine officers, was £1,408,437, and the sum voted for the extraordinary expenses, including the building and repair of ships, was £2,296,030. These, and the various other sums voted for the naval service of the year 1809, amounted to £19,578,467; and this total showed an increase of nearly a million and a half sterling, for carrying on the services of the navy during the year 1809.

Those French ports which contained any material force of ships of war were still blockaded by the English; the principal being Toulon, off which lord Collingwood held the command, and Brest, which was watched by lord Gambier. But before the end of February the blockade of Brest was suspended, in consequence of the prevalence of a westerly gale, which obliged lord Gambier to retire from immediately before the port; and as soon as the state of the weather allowed, during the absence of the blockading fleet, the French admiral left the port: this was on the 21st of the month. It happened, however, that at this time a British man-of-war was sufficiently near to perceive what had occurred; and this sailed immediately to join a blockading squadron off L'Orient, and to communicate information to the commanding officer of that squadron, of what had taken place. A very short time elapsed before the two squadrons were sufficiently near to be seen from each other. There was also a squadron of three ships of the line at anchor upon the coast, commanded by rear-admiral Stopford, to whom information was likewise very promptly communicated. He got under weigh, and chased the French squadron, which on the morning of the 24th entered Basque roads. Here they were subjected anew to a blockade by rear-admiral Stopford's squadron, until this was joined by one under lord Gambier, who assumed the command of the whole, and continued the blockade. His fleet, composed of three squadrons, which had occupied separate stations, amounting to eleven sail of the line, was now anchored in Basque roads.

The design was now conceived of destroying the enemy's ships under blockade, by means of fire-ships; and when information of the enemy's situation became known in England, the admiralty at once considered that such means might be employed with success, even before receiving admiral lord Gambier's despatches on the subject; and conferences were had with captain lord Cochrane, who was known to be acquainted with that part of the coast. That officer confirmed the opinion of the admiralty as to the practicability of carrying the project into full effect against the French; and when it was determined to employ a force of fire-ships for that purpose, lord Cochrane was appointed to direct the operations of these ships, under the orders of lord Gambier.

Great preparations were made towards accomplishing this object. Seven frigates, and sixteen smaller vessels were ordered to attend the expedition; and twelve fire-ships and six transports, with a view to being fitted up and employed in the same manner, were ordered, with a considerable number of other transports, to proceed to the coast of France.

It was not until the 11th of April, that the whole of the arrangements were completed; and on that night circumstances were favourable for making the attack. But, as the fire-ships advanced, it was discovered that means had been taken to defeat such an attack. A strong boom, of about half a mile in length, had been constructed across the navigable part of the road. This was, however, broken by the largest fire-ship when she arrived; and the passage was rendered clear for the ships which followed. It does not appear that from this stage of the service there was that cool and steady decisiveness of action that such an occasion required. Some of the fire-ships were abandoned too soon, and were consumed without performing any part of the service required of them. But, when the French saw the large number of these ships approaching them, they cut the cables of their ships; and considerable disorder amongst them occurred in their efforts to avoid a collision.

The *Ocean*, of one hundred and twenty guns, the French admiral's ship, was grappled by a fire-ship; but by the most energetic and persevering exertions she was disengaged; and the fatal consequences of the contact were narrowly escaped. The *Regulus* of seventy-four guns was in similar danger. Fourteen ships, out of the fifteen which had been lying there, either cut or slipped their cables: one of these brought up again; and thirteen of them went upon a lee-shore.

Not one of the French ships was destroyed by the fire-ships which were expended, although they were so numerous. When day-light discovered to the English the fleet which had so narrowly escaped their efforts at destruction, the French were seen to be making the greatest efforts towards getting off their grounded ships; and with respect to the most of them, their efforts were successful. But, three line-of-battle-ships, a 50-gun ship, and a frigate were destroyed; two of these, the *Tonnerre* of seventy-four, and the *Indienne* of forty guns, were destroyed by the French, in consequence of their being unable to remove them from the shore.

One bomb and several gun-brigs were ordered by lord Gambier to attack the ships as they lay upon the shore; the two ships which had not been on shore weighed and stood for the Charenk; but at the entrance of that river they both grounded; several other ships, as soon as they were got afloat, followed them; but these grounded also. These successful results of the French, showed that unless the English were now prompt in what remained for them to do, the object of their expedition would be altogether frustrated. They therefore made their attack upon such of the enemy's ships, as the brigs under lord Cochrane's orders were able to bring their guns to bear upon. Under the force of this attack, the *Varsovie* of eighty, the *Aquilon* of seventy-four, and the *Calcutta* of fifty guns, surrendered, and were destroyed by the English. The *Tonnerre* and the *Indienne* were not destroyed until very persevering efforts had been made by their respective crews to save them; but without success.

This very partial success was highly satisfactory to lord Cochrane, who considered, however, that he ought to have been supported with more energy by lord Gambier, with the ships under his command. The event brought no prize to the English; whilst the French themselves considered that their fleet was so exposed, that if the affair had been conducted in a proper manner, the English might have either taken or destroyed all the ships of which it was composed.

Within a period of four or five years, the Scheldt had become a very important naval station; the resources for building, which were of easy access, having induced the emperor of France to construct a dockyard and an arsenal here, together with such fortifications as appeared requisite to give security to those establishments.

Against this station, the government determined to send, in the summer of 1809, an expedition on a large scale; but the intention of this project was permitted to transpire, and a period of two months to elapse between forming the plan, and carrying it into effect. The consequence was, that before the expedition left England, the design of sending it was well known upon the continent.

The expedition did not leave England until the 28th of July. The fleet consisted of thirty-seven ships of the line, two of fifty guns, and three of forty-four; twenty-three frigates, one 20-gun ship, thirty-one sloops, twenty-three gun-brigs, five bomb vessels, and a large number of tenders, cutters, gun-boats, &c.; and about four hundred transports:—amounting, in the whole, to nearly six hundred and fifty sail. The naval command was given to rear-admiral sir Richard J. Strachan. There accompanied the expedition an army of more than thirty-nine thousand troops, under the command of the earl of Chatham.

The object contemplated in sending so large a naval and military force to the Scheldt, was the capture or destruction of all the French ships which should be found lying in the river; and the demolition of the dockyard and arsenal, and the fortifications which had been recently constructed;

but as to the ships, it was soon found that they could be withdrawn so far up the river, as to be secure from any attack the English could make upon them. The citadel of Antwerp commanded the dockyard; and the city itself was discovered to be strongly fortified, and to be capable of the further protection of having the approaches to it inundated.

The English gained, however, some advantages, in attacking the fortifications upon the banks of the river; they obtained possession of the navigation of the western Scheldt, and established the blockade of Flushing by sea and land, and on the 15th of August that city was surrendered by capitulation.

When this place fell into the hands of the English there were three ships on the stocks: one of seventy-four guns, a frigate, and a brig; the two latter were destroyed with the dockyard; but the timbers of the other were brought away, and the ship was afterwards built at Woolwich, and launched in 1812, and named the *Chatham*. She was 1860 tons burthen, and measured 177 feet 9 inches in length on the gun-deck, 48 feet 10 inches in extreme breadth, and 21 feet 6½ inches depth in the hold. A new 38-gun frigate, lying at Flushing at the time of the surrender, fell likewise into the hands of the English.

In the month of October a squadron of line-of-battle-ships and frigates, having under their convoy a fleet of store-ships and transports, quitted the harbour of Toulon, during a temporary absence of lord Collingwood's fleet. As soon as this movement was perceived from a British frigate, this frigate sailed to convey the intelligence to lord Collingwood; and it was supposed that the whole of the Toulon fleet had followed those which were seen to be leaving the port, since information, which had been communicated to the English, had led them to conclude that the relief of Barcelona was the object for which this French fleet had sailed.

Lord Collingwood therefore took his station with the view to intercept the French, if such should be their destination. The fleet which he commanded consisted of fifteen ships of the line, and a small number of inferior rates. The frigates were ordered to look out for the enemy, and preparations were made for action. On the evening of the 24th, three ships of the line and a frigate were seen, and chased; the pursuit was renewed on the following morning, when two of the French ships, one of eighty and the other of seventy-four guns, ran ashore near to each other: these ships were set on fire by their crews and abandoned. The other 74-gun ship and the frigate entered the harbour of Cette, from which they afterwards returned in safety to Toulon. Several of the vessels which had left Toulon under convoy were captured; the others, with the light vessels forming a part of the convoy, entered Spanish ports, where they had the protection of strong batteries. This advantage did not, however, secure them; for, on the night of the 31st, a very strong detachment of boats was sent into the bay of Rosas, and, against the force of well arranged means of defence, and a very brave resistance, the English were completely successful in capturing the eleven vessels which had taken refuge there; some of which they destroyed, and the rest they carried off as prizes. The blockade of Toulon was resumed by lord Collingwood.

The British cruisers were very active during the year; and, considering the general restraint and caution which controlled the operations of the French navy, their activity was not without success. The loss to the French navy by the intervention of the English was two ships of eighty guns, four of seventy-four, one of fifty, twelve frigates of forty guns, two of thirty-six, and one of twenty-eight, besides smaller vessels. Of these, one 74-gun ship, five frigates of forty guns, two of thirty-six, and one of twenty-eight, and several corvettes and gun-brigs, were included amongst the prizes.

Very different were the casualties of the English navy. The *Agamemnon*, of sixty-four guns, was the only ship above the rate of a frigate that was lost, and this ship was wrecked in South America; one frigate of thirty-eight, and another of thirty-two guns, were captured by the enemy, and three frigates of the latter class were wrecked; three sloops foundered, five were wrecked, and two were captured; two gun-brigs foundered, three were wrecked, one was burnt, and one was captured; one cutter foundered, five were wrecked, and one was captured; one bomb-vessel, of eight guns and two mortars, was wrecked; and one troop-ship was converted into a fire-ship, and used in that capacity in the attack of the French fleet in the Basque roads. Hence it appears, that out of thirty-two ships and vessels of which the British navy sustained the loss during the year 1809, only six were lost by the intervention of the enemy. One ship of sixty-four guns, one of sixty, and twenty frigates and inferior vessels, were either broken up or sold; making the loss fifty-four sail.

To be placed against this reduction there were eight ships of seventy-four guns, eight frigates, and seven sloops, launched within the year; and one gun-brig and three cutters were brought into the navy, besides prizes which had been taken from the enemy. There were also ordered to be built three 74-gun ships, three frigates, one sloop, and six cutters; and there was a considerable number of ships, both of the line and below that rate, in the course of building at the end of the year. The effective navy of England had, therefore, declined to some extent within the last twelve months.

At the beginning of 1810 there were a hundred and eight ships of the line, and five hundred and fifty-six ships, frigates, sloops, brigs, cutters, &c., in commission as cruisers. This was a diminution of twenty sail in the whole. There were also fewer by nine lying in ordinary for sea service, than there had been at the commencement of the preceding year.

The numerically small diminution in the ships of the British navy appears, in the estimation of the admiralty, not to have impaired the general capabilities and efficiency of that establishment; for the number of men required for the service of the navy in 1810 was increased by fifteen thousand seamen, making the total number of seamen and marines a hundred and forty-five thousand men. These were provided for at the rate of four pounds two shillings and ninepence for each man per month; the sum voted for the ordinary expenses of the navy was £1,511,075, and that for the extraordinary expenses was £1,841,007: these, and other sums voted for carrying on the different branches of the naval service for the year, amounted to £18,975,120.

There were few opportunities presented during the year by the enemy, for calling into exercise the force of a British fleet. The principal part of the French navy lay at Toulon, subject to the blockade of an English fleet. Ill health obliged lord Collingwood to resign the command of this station early in the year: on the 5th of March he sailed from Minorca on his way to England, and died two days afterwards. Admiral sir Charles Cotton succeeded him in the command, and continued the blockade of Toulon. The French were intent on realizing a continual increase by the building of ships of war, both at this port and others; but although there was sometimes only a small squadron off the port of Toulon, no vigorous attempt appears to have been made to release the port from the restraint which even a moderate force imposed. On two occasions, however, in July and August, when the blockading force was very small, and some store-ships inadequately protected were approaching, and in danger of being captured by the English, sufficient squadrons were sent out to protect them, and partial, but inconsequential encounters between them and the English took place: they merely performed the service for which they had been sent out, and returned, with their charge, into the harbour.

The enemy's light cruisers, and also a considerable number of very superior privateers, were actively employed in the European seas and in the British channel; and as the objects of attack of these vessels were the coasting and other trading vessels belonging to England, considerable injury was sustained by their depredations. Hence considerable activity in the British cruisers was called forth against them, and a number of them fell into the hands of the English during the year. Some of the privateers that were captured were very fine vessels, and nearly new.

The success of the English against the national cruisers of the enemy was not great. One 40-gun frigate was captured on the coast of France, and another was destroyed: besides these none, except of inferior rates, were either taken or destroyed in the European seas; but in the Mediterranean and Adriatic, wherever the French national cruisers or privateers were in exercise, thither, almost certainly, one or more British cruisers were attracted.

A number of very spirited attacks were made upon the islands and colonial settlements of both the French and Dutch; and for the most part they were successful. In the Adriatic sea a British squadron attacked the island of St. Maura, which was occupied and garrisoned by the French. The operations by which the garrison was reduced to the necessity of capitulating were partially military, a body of troops having been taken for this service. The ships employed in the reduction of the island were two of seventy-four guns, two frigates, and a 16-gun brig-sloop, accompanied by some gun-boats.

In the Indian Ocean the Isle de Bourbon, and the Isle de la Passe, were taken; but the latter was recovered by a French force, which arrived some time afterwards. In this affair the English unfortunately lost three frigates; one of which, having been very much damaged, was obliged to surrender, and the two others, being unable to retire beyond the fire of the enemy's frigates, were set on fire and abandoned. The isle of France was also attacked by a considerable force; the naval part of it consisted of one 74-gun ship, twelve frigates, and a small number of sloops, brigs, &c., accompanied by a considerable number of transports, for the conveyance of troops.

Early in the year a small force sailed from the East Indies, under the command of captain Tucker, in the *Dover* 38-gun frigate, against some of the Dutch settlements in the Malay Archipelago. By a series of successes the English became possessed of the island of Amboyna, and of several other islands which had been occupied by the Dutch; and in July a squadron under captain Cole reduced the Dutch island of Banda.

In the West Indies a naval expedition, accompanied by a considerable military force, proceeded early in the year against the French island of Guadaloupe; which, in a few days after the British forces had been landed, surrendered by capitulation. The surrender of this island was soon followed by that of the Dutch islands of St. Martin, St. Eustatia, and Saba; and by this expedition both the French and Dutch were dispossessed of the last of their colonies in the Antilles.

The direct results to the British navy, of the activity of its cruisers during the year, were very small. At the isle of Bourbon one 40-gun frigate was captured; and four others of the same rate, three brigs, together with some Indiamen, merchant ships, &c., that had been captured, were taken at the reduction of the isle of France. At the same time two 36-gun frigates, which had been previously taken from the English, were recaptured. Only three of the frigates, the frigate-built store-ship *Necessité*, and a sloop, were added to the British navy.

The losses of the English included one 74-gun ship, the *Minotaur*, which was wrecked at the mouth of the Texel; one frigate of thirty-eight, five of thirty-six, and one of thirty-two guns; two sloops of sixteen, and two of ten guns; one 12-gun brig; one cutter of twelve, two of ten, and one of four guns. The two 36-gun frigates which were captured by the French, were recovered as already mentioned. The only other vessel that fell into the hands of the enemy was the *Alban*, 10-gun cutter, which was captured by some Danish gun-boats. The *Satellite*, 16-gun brig-sloop, and the *Conflict*, 12-gun brig, foundered; all the others were wrecked, with the exception of the two frigates which, in the attack of the French frigate-squadron at the isle of France, accidentally grounded, and were destroyed to prevent their becoming prizes to the enemy. Separately from the losses sustained by the navy, that establishment was further necessarily reduced during the year, by the wearing out of ships: four ships of the line, and twenty-eight ships and vessels under the line, were sold or broken up during the year.

The ships launched in the government dockyards were the *Queen Charlotte*, of one hundred guns and 2289 tons; the *Impregnable*, of ninety-eight guns and 2278 tons; the *Boyne*, also of ninety-eight guns, and 2155 tons; and four frigates. Eight 74-gun ships were launched in private yards, the average burthen of which was 1763 tons; and one, the *Minden*, was launched at Bombay of 1656 tons. There were also launched in private yards six frigates, two 18-gun sloops, and six 10-gun cutters: making a total of twelve new line-of-battle-ships, and eighteen ships and vessels of inferior rates. Five ships of the line, and eleven of inferior rates, were ordered to be built; some of which were launched within the year.

A material diminution occurred during the year in the number of cruisers. The line-of-battle-ships, of which there were one hundred and seven in commission, had been reduced in number by only *one;* but those of inferior rates had diminished in number from five hundred and fifty-six to five hundred and thirteen, making a difference of forty-three. In ordinary, for further service at sea, there were seventeen ships of the line, and twenty ships and vessels under the line. The ships and vessels which had taken their final station in harbour, were rather increased in number during the year.

There were a hundred and forty-five thousand seamen and marines voted for the service of the navy in 1811, as in the preceding year, in the same proportions, and with the same allowance for their maintenance; and the sums voted for the ordinary and extraordinary expenses of the navy were £1,578,113, and £2,046,200; and the entire supplies granted for the naval service were £19,822,000 sterling.

The only station, on which it was necessary to maintain a strong fleet as a blockading force, was still off Toulon. The fleet within that port was gradually increasing, and a part of that increase consisted of very large ships of the first rate. In other ports, also, the building of ships was carried on with persevering diligence. The principal service of the Mediterranean fleet continued, therefore, to be off Toulon; but as the French admiral, whenever he conducted his fleet outside of the road for the exercise of the seamen or other purposes, performed that service with too much caution to place it in the power of the English admiral to bring on a general engagement; so nothing on a large scale, affecting the interests of the hostile navies, was performed by the British fleet.

Towards the end of the summer there was a revival of hostile appearances, connected with the flotilla which had been provided and assembled at Boulogne with the design of being employed in the invasion of England. In the month of September, when Napoleon was inspecting that force, a squadron of prames, or flat-bottomed boats, was ordered to attack the British frigate *Naiad*, which was lying at anchor at some distance from the shore. The attack of the prames was soon followed by that of a squadron of brigs. At length the frigate got under weigh, to obtain for herself an advantageous relative position; when her opponents retired towards the shore, that they might have the protection of the batteries. Before any operations began on the following morning, the frigate had been joined by an 18-gun brig-sloop and two 10-gun sloops, and a cutter of eight guns. A squadron of brigs, prames, &c., was perceived, early in the day, to be preparing for operations. A partial engagement took place, in which some loss was sustained by the English; who, however, captured one prame, when the rest of the prames and the brigs retired within the protection of the batteries.

In the month of March a very brisk engagement took place between two squadrons of frigates. The British squadron consisted of the three frigates *Amphion*, *Cerberus*, and *Active*, and the 22-gun ship *Volage;* and that of the enemy consisted of the six French and Venetian frigates *Favorite*, *Corona*, *Bellona*, *Carolina*, *Danae*, and *Flore*, and the 16-gun brig-corvette *Mercure*, a 10-gun schooner, a 6-gun xebec, and two gun-boats. Whatever was apparently deficient on the part of the English was amply supplied by their well-formed resolution, supported by skill and bravery. In an early part of the engagement the *Favorite* ran ashore, and remained there. The action was continued with great ability on the part of the English, whose inferiority in numbers gave the enemy a great advantage. The *Amphion* was at one time engaged with two frigates—the *Bellona* and *Flore*—one on each quarter. From this awkward position she succeeded in releasing herself, and proceeded to engage the most powerful of the two frigates, which was compelled to surrender; and, without waiting to take possession of her, the *Amphion* hastened to bring to close action the *Bellona:* this frigate too was obliged at length to strike; and this second surrender determined the result of the engagement, for the unsubdued ships then endeavoured to escape from further conflict. One of the British frigates and the *Volage* were much damaged in their rigging, and rendered unfit for pursuit; and of this circumstance the *Flore* took advantage, and escaped. The *Active*, which remained in the best condition for service, pursued, engaged, and captured the Venetian frigate *Corona*. This closed the action in a manner quite different from what the superior force of the enemy appeared to justify them in expecting; and being near to Lesina, the three frigates which had escaped, and the inferior vessels, secured themselves by entering the harbour of that island. A flag of truce was afterwards sent, with a demand to have delivered up the *Flore*, which had escaped after submission. This was, however, refused, as it was alledged that her colours had been shot away in the action, and not hauled down; but the contrary to this was known to have been the case. The loss of the enemy's squadron amounted, therefore, to only three frigates; two of which were prizes in the hands of the English, and the *Favorite,* which, having accidentally run ashore, was set on fire by her own crew and destroyed.

Nor were the naval services of the British in the East Indies of an inferior character. The greatest skill and intrepid exertion were conspicuous in the train of services by which the island of Java was captured. The expedition which was fitted out for this purpose consisted of three ships of seventy-four guns, and one of sixty; one frigate of forty-four, four of thirty-eight, six of thirty-six, and three of thirty-two guns; and seven sloops, together with several cruisers belonging to the East India company; and a considerable number of transports and gun-boats. Beyond the small service of getting possession of a few forts and batteries, which was performed by the ships, the result of the expedition in reducing the island depended chiefly upon the military part of the enterprise; for there were few proper objects for naval service. Two French frigates were at the island when the English arrived, and these were chased by an English frigate and a sloop; but they succeeded in escaping from their pursuers.

No ships above the rate of a frigate were captured by the English during the year. Three 40-gun frigates were taken from the French, and one 40 and one 38-gun frigate from the Venetians. Two French 40-gun frigates were destroyed, after having been run ashore; one in attempting to escape from a British ship of the line, and the other in the frigate-squadron engagement in the Adriatic, as has been mentioned, and one was wrecked.

The losses which the British navy sustained far exceeded the amount of its prizes. The *St. George,* of ninety-eight guns, and the *Hero* and *Defence,* of seventy-four, were wrecked on the coasts of Holland and Denmark, on their return from the Baltic in the month of December; two frigates of thirty-eight, two of thirty-six, and one of thirty-two guns, were also wrecked; one 18-gun brig-sloop was wrecked; two of the same class, and a 16-gun sloop were captured; one 12-gun brig foundered, two were wrecked, and two were captured by the Danes; one 10-gun brig was wrecked, and one foundered; two 10-gun cutters were wrecked, and one was captured; one 4-gun cutter was wrecked, and one was captured; and the *Chichester,* store-ship, was wrecked in the East Indies: making a total loss of twenty-five sail of all classes. In addition to the losses, the navy was further materially reduced by breaking up or disposing of such ships as had become unserviceable. These amounted to three ships of the line, and fifty-one of inferior rates.

The ships launched within the same period did not compensate for these diminutions. They were the *Union* of ninety-eight guns; the 74-gun ships *Alfred, Asia, Barham, Duncan, Edinburgh, Hogue,* and *Stirling Castle;* one frigate of thirty-eight, and three of thirty-six guns; one 20-gun flush-decked ship; and two 10-gun cutters. Two 74 and two 50-gun ships, one

36-gun frigate, one 20-gun ship, two 18-gun ship-sloops, fourteen 18-gun brig-sloops, twelve 12-gun brigs, and two 10-gun cutters were ordered to be built; and a small number out of these thirty-six which were ordered to be built, were launched within the year; but this left a considerable reduction in the entire navy, as it stood at the beginning of the year 1812.

At this period there were in commission as cruisers a hundred and two ships of the line, and four hundred and eighty-two ships and vessels of inferior rates. In ordinary, for further service at sea, there were eighteen ships of the line, and twenty-one under the line; forty ships of the line, and ten under the line, were in commission for harbour service; and forty-six of the line, and ninety-six of inferior rates, were lying in ordinary.

Previously to the year 1801, the master-shipwrights and their assistants, received a low salary, with certain perquisites, as a compensation for the difference between their salaries, and the value of their services. One of these, consisted in the privilege of taking apprentices,—the master-shipwright being permitted to have five. These were generally youths who had received a better education than those who were bound to the labouring mechanics of the dockyards; and a premium was always paid with them, as a compensation for the professional instruction which they were to receive; and it was from this class of apprentices, that the dockyards were supplied with professional officers. As the premiums were often large, this source of emolument added very much to the value of those appointments in the dockyards which gave the privilege of taking such apprentices. But, it was considered, that the system was very likely to be abused; and there can be but little doubt, that the discretionary power vested in the officers, was sometimes abused; although practices which were strictly an abuse of power, were not only in conformity with the usages of the establishments, but were authorized by the regulations of the service. And, even in instances where the officers might act with the most exemplary integrity and impartiality, they were sometimes suspected of acting otherwise; they suffered, therefore, through the defects of the system under which the affairs of the service were managed.

But the system was not defective in that respect alone. The means of professional instruction which it provided, were not such as are necessary to develop and cultivate those faculties of the mind which are required in an officer, whose duties need the constant exercise of thought, ingenuity, precision, and confidence; nor was it calculated to qualify for the performance of those official duties which are necessarily connected with the carrying on of the public service with efficiency. There was commonly a deficiency of the energy which is always needed in carrying out plans of extensive improvement; and an absence of that freedom and expansiveness of thought, which are shown in forming original schemes and projects of usefulness: Professional knowledge was almost entirely of a practical kind;

sufficient for the purpose of building ships; and to form an adequate judgment generally, of things lying immediately within the limits of their duties. Indeed, towards the close of the last century, the ships appear to have been distinguished by remarkable strength and durability: for, from the commencement of the revolutionary war, until peace was restored, the ships of the British navy were employed almost incessantly in the most arduous services, for which they seemed to be eminently suited.

In the unremitting assiduity of public duty in the dockyards during that period, the officers, doubtless, carried on the works with energy and despatch; and this must have contributed most materially to the efficiency of the fleet. It is true, that during that period, there were several instances of turbulent insubordination amongst the workmen; but the moral power which the arrangement of the service, at that time, enabled the officers to exercise over them, was so well employed, that order was speedily restored, and the duties of the yards were carried on with the greatest vigour and efficiency.

The regulations which were introduced into the service in 1802, and continued till 1804, were not adapted to supply the dockyards with officers of equal efficiency. For, most of the apprentices that were taken in during that period were without education, and therefore, in addition to the want of intelligence necessary to official competency, their sentiments and associations were very different from those which would fit them to command with proper effect. Besides this original disadvantage, to which the apprentices of this period were subject, there was no system of efficient instruction under which those disadvantages could be made to disappear; or that should fit them generally for superintending and carrying on the important duties of ship-building. They were not taught to work from designs; nor to lay off ships systematically on the mould-loft floor; although this is a part of the instruction which it is most material should be known; and it is necessary, to the efficient discharge of the duties of a dockyard, that even the subordinate officers should be acquainted with this branch of the profession.

It would certainly be an advantage to the practical mechanic, that he should possess some amount of theoretical knowledge; it is necessary only to perceive the intimate connection which subsists between the theory and practice of ship-building, to be aware that such knowledge would be useful to him, in proportion as it was possessed. Thought, discretion, and skill in various degrees, are required of the workman in executing those plans which are brought forward by the master; and a due degree of theoretical knowledge enables him to execute with confidence and accuracy the various practical operations of his art. And hence, it is evident, that the interests of the service may be promoted, by having the workmen properly trained, not only to the efficient exercise of their muscular powers, but in the discipline and cultivation of their minds; and it is much to the credit of Her Majesty's government, that schools have been recently established in the dockyards for the better education of the apprentices.

It was in consequence of some statements in the report, in 1806, of the commissioners appointed for revising the civil affairs of the navy, that the government determined to establish a system of education for a superior class of shipwright-apprentices, with the view to obtain efficient officers for the dockyards. This plan was first brought into operation in January, 1811, by the introduction of apprentices, to be educated at the royal naval college in Portsmouth dockyard.

The admission of this superior class of shipwright-apprentices, and the establishment of the School of Naval Architecture, which was intended to give effect to the design, promised the greatest advantages to the service, by providing a class of officers of superior education and talent. The candidates for admission to this school were selected according to their merit; whilst the standard of required previous attainment was placed so high, that youths within the age at which they were eligible, could not, without very creditable mental endowments, reach it, and the examinations of the candidates were conducted with the strictest regard to merit.

It was the object in that establishment to combine a systematic and comprehensive course of instruction in those parts of mathematical and mechanical science which are either directly or remotely connected with naval architecture, with a complete course of practical instruction in every branch of the art of ship-building; and throughout the course of education at this establishment, a general emulation was carefully excited and sustained, whilst the whole was eminently fitted to qualify young men for the important duties of a ship-builder and naval architect.

It is frequently observed, that theoretical men attach a degree of importance to the principles on which their reasoning is based, which is almost exclusive; and in their partial regard to theory, they often develop it with too little consideration whether it is in a state in which it can be applied to practice. At the same time, merely practical men, who can seldom appreciate what is purely theoretical, are too ready to despise its application to the objects of their profession. Thus, between these two extremes, the important fact is often overlooked, that there cannot but subsist a most intimate connection between true theory and practice,—a connection, indeed, so absolute, that whatever is true in either of them, cannot be at variance with what is correct in the other.

The true principles of theory must ever constitute the basis on which improvements can be carried on with certainty; for theory comprehends the facts which practice has to meet, and having generalized them, exhibits the principles of correct practice. And hence theory, without reference to practice, is nonsense. Practice comprehends a set of operations or experiments which are not necessarily methodized; whilst theory includes any class of generalized or philosophically arranged experiments. Practice has reference to a design already formed; and its perfection consists in executing such design without fault. Theory supplies the principles upon which improvement may be carried on with confidence to perfection; it is essentially the basis of improvement, although it may not always be recognized as such; whilst it is allowed that merely practical knowledge may enable a person to correct many obvious defects in practice, without referring to any general principles as a guide.

It was long the bane of the British naval service, and the obstruction to improvement in ship-building, that science was discouraged, and too much confidence was placed in what is commonly called experience, which sometimes includes a great amount of error, and constitutes a barrier to enlightened improvement.

As it regards the instruction which was given at the School of Naval Architecture, even omitting the scientific studies of the apprentices, it may be shown that their professional instruction was very superior to any that apprentices in the dockyards had previously received. The students were obliged not only to work at their tools three days in the week, to become acquainted with the general operations of the workmen; but they were required to systematize, under strict examination, all that they had observed, embracing the methods used by the workmen in taking an account of work, and in trimming and *faying* particular timbers in a ship, for which the best workmen are usually employed. On these subjects, as well as on all others connected with the practice of ship-building, as forming and combining the various parts of the structure, according to the different systems which were brought under their notice, suitable explanations were given to them; and they were required to reason on these subjects, as there are always grounds of preference to one mode over another. In addition to this they were taught to make draughts of ships, and to lay off the body on the mould-loft floor; and the assistance which they derived in this part of their professional studies from a knowledge of geometry, enabled them to do it not only with facility, but with that degree of accuracy which alone can ensure the proper shape to the ship. This was sufficiently manifest in the ships which, in the course of their professional studies, they laid off. For receiving and practising this part of their instruction, the forenoon of each of the first three days in the week was set apart, and also every morning before breakfast. They had also to study mast-making, and every other part of the profession that was calculated to make them accurately acquainted with the practical details of the construction, the fitting, and the repairs of the various kinds of ships.

The scientific part of their instruction consisted in "preparatory courses of algebra, geometry, trigonometry, mechanics, hydrostatics, and the differential and integral calculus." After the students had gone through these subjects, they began a strictly professional course of reading on the theory of naval architecture, and the construction of ships, according to a system as ably conceived as it was carefully and successfully developed by Dr. Inman, the professor of mathematics at the royal naval college. The time allotted to these studies was the first three afternoons in the week; but as much time and close attention were required to be devoted to these subjects, the evenings were generally given up likewise to the study of them, to the keeping up of their knowledge of the subjects which they had already studied, and to preparation for the strict examinations which they had to pass, in all the branches of their previous study.

These examinations took place every Christmas, and they were conducted partly by papers containing questions on every subject connected with the studies they had passed through, and partly *vivâ voce*. These required the most indefatigable application of the students. The examinations were conducted under the direction of Dr. Inman, whose abilities for the duties of that establishment could perhaps hardly be exceeded. He was assisted, in the preparatory course, by the first mathematical assistant of the naval college; and as the selection of both professor and assistants had been most judicious and successful, so the students had the greatest advantage in the prosecution of their mathematical studies.

The students were bound, for the term of seven years, to the superintendent of the school of naval architecture; and after the expiration of this term they were, according to the regulations under which they had entered, to fill the situations of master boat-builder, master mast-maker, assistant to master shipwright, mechanist in the offices of the inspector-general of naval works, civil architect and engineer, assistants to the surveyor of the navy, master shipwrights, second surveyor of the navy, inspector-general of naval works, and first surveyor of the navy.

After the students left the school of naval architecture, they were sent to the navy-office, to become acquainted with the methods employed there of draughting and constructing ships; they were also sent to the different offices in the dockyards, to learn the routine of their respective duties; and, finally, they were sent to sea in the experimental and other ships, with instructions to make their own observations on the sailing and other properties of the ships, on which they were respectively to report.

Thus all was done that could be done, to render them efficient professional officers of the dockyards; but it is much to be regretted, that through the jealousy or mistaken views of the officers of the dockyards, several of those, of whom there was a prospect that they would become ornaments to their profession, were lost to the service. This loss may be attributed to the erroneous notions about experience. The students left the school of naval architecture after having obtained all the professional information that could be useful; but the experience that would give confidence in the execution of the different works connected with ship-building, must be gained in those situations to which they would be appointed; and it rested with the officers of the dockyards to afford them the facilities of gaining this experience. It was necessary that they should feel some weight of responsibility, otherwise they would fail of having sufficient objects to engage their attention, and mature their knowledge in the course of practical duty. Without this responsibility there would be nothing to call into use the knowledge they had acquired, and which had become the great object of their ambition to apply to particular purposes. A course of duties involving no responsibility, and therefore requiring no exercise of that knowledge which they had acquired with so much labour, would be distasteful, give rise to feelings of disappointment, and lead to indifference. The consciousness of responsibility was essential to the maturing of their qualifications as efficient officers of the dockyards. If the School of Naval Architecture had failed, it would not have been through the want of information, either practical or theoretical, which became the proper objects of attention to the students.

It is hardly possible to conceive the idea that any really intelligent person at all conversant with the character of naval architecture, should fail of recognizing the importance of a superior education to a ship-builder. His duties fall below those of no other class of persons, in requiring a thorough knowledge of established principles in natural philosophy. Mathematical science has developed the principles, and simplified the rules, in accordance with which we can carry out some of the most valuable principles in the construction of ships; and every failure in construction may be attributed to the neglect of some of these principles, or to a want of acquaintance with others which have yet eluded discovery, as those of the resistance of fluids, and other points which experiment alone can never determine.

A thorough knowledge of the principles of mechanics appears essential, to guide in the proper disposition of the weights of so complicated a machine as a ship; to prevent excessive violence of motion in a tempestuous sea; and to render a ship's motions, both lateral and longitudinal, as limited and easy as possible; as excessive motion must not only endanger the safety of a ship, but destroy the comfort of every one on board, and certainly impede the sailing, and prevent precision in firing the guns.

A competent knowledge of chemistry would likewise be of much advantage to a ship-builder, as it would disclose to him accurate views of the nature and properties of the various materials entering into the composition of a ship, and teach him to combine such substances only as are not calculated to produce injurious effects on each other, through their peculiar chemical properties; while, by an acquaintance with chemistry, his observations are directed to appearances constantly occurring in the execution of his duties, which would otherwise escape his notice.* The knowledge of the best means of preserving a structure from decay, and rapid deterioration, is scarcely less important than that of the best methods and principles for conducting its original formation.

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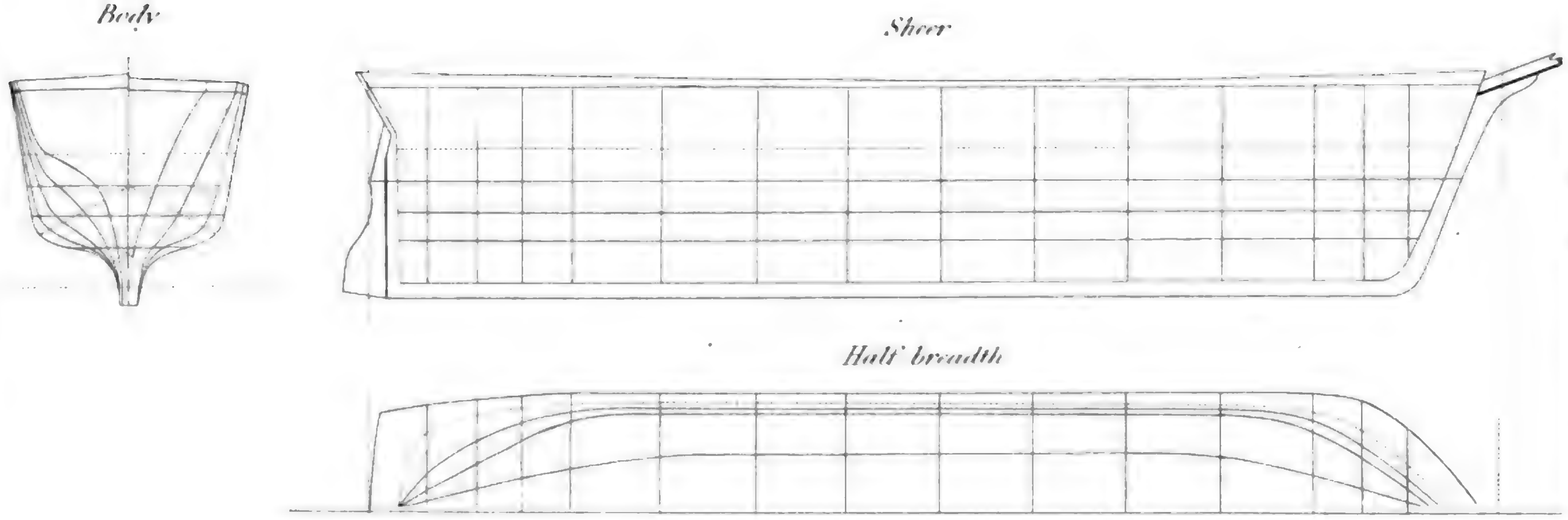
* Since the above was written, the Admiralty has appointed a chemical lecturer to the dockyards; which must ultimately prove of great benefit to the service.

The supplies voted for the navy for 1812 were still a hundred and forty-five thousand seamen and marines; and these were provided for at the rate of four pounds two shillings and ninepence a man per month. The sum voted for the ordinary expenses of the navy, including half-pay to naval and marine officers, pensions, &c., was £1,447,125; and that for the extraordinary expenses, including the building and repair of ships of war, and other works connected with such services, was £1,696,621: these sums, and others which were voted for the wear and tear of ships, naval ordnance, and all other purposes for carrying on the naval service, amounted to the total sum of £19,305,759.

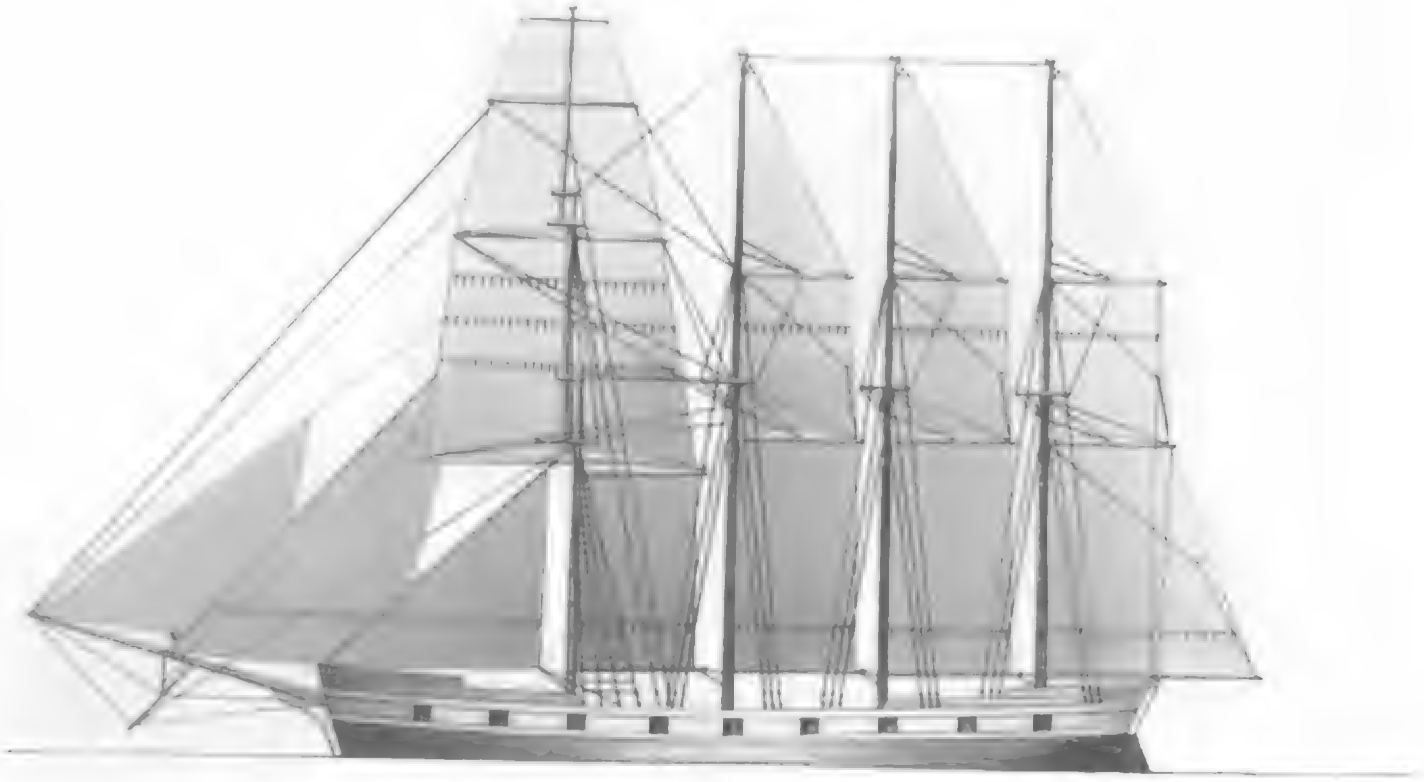
Several vessels built about this period claim to be noticed, more on account of the peculiarity of their construction, than for any remarkable excellence which they exhibited: these were the *Transit*, the *Inspector*, and the *Spanker*, floating battery.

The *Transit* was designed by Mr. Gower, an officer in the East India Company's Service, and was launched at Itchenor, in Sussex, in the year 1800. She was a vessel of peculiar construction, and was intended for the packet service. In her first trials she showed superior qualities as a sailer and a sea-boat; and having attracted the attention of the royal squadron in July, 1801, and previously, that of earl Spencer, when he was first lord of the admiralty, and having subsequently established her character as a fast sailer, the earl St. Vincent, now first lord of the admiralty, ordered her to be tried against the *Osprey*, a fast sailing sloop of war, of 383 tons, commanded by commander Irwin, in July, 1801; and it appears by the official returns, that the *Transit* had great advantage, both close-hauled and large; that in blowing weather she was much easier and drier than the *Osprey*; and that when pressed under trial, her greatest angle of heeling was about ten degrees. Although this vessel had displayed great superiority in sailing, as well as in other essential properties, yet she was allowed to take on board a cargo, and to sail with a convoy of merchant vessels: in this service her good qualities as a sailer were still displayed and noticed, particularly by captain Paget, of the *Hydra*; and it appears that they were not less conspicuous in subsequent voyages which she made as a trading vessel. She was fitted with bulkheads at certain distances from the head and stern, with the view to give transverse strength, and also to keep the weights away from the extremities.

From her acknowledged good qualities, the late lord Vernon had a yacht built on the reduced lines of the *Transit*; and this vessel is said to have possessed weatherly qualities, and to have sailed well; but it is said she was not stiff under canvas.


Body
Sheer
Half breadth

THE TRANSIT, PLAN OF THE SAILS.



INSPECTOR AND CORNWALLIS.

Fig 1. The Inspector

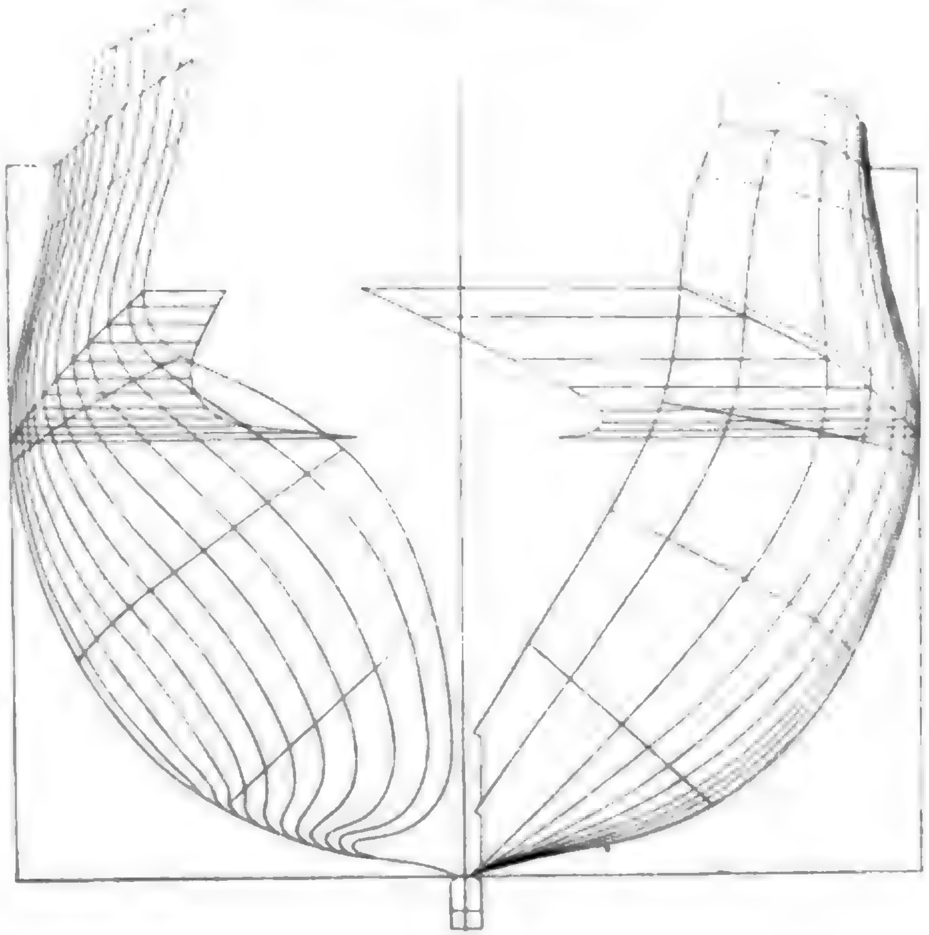
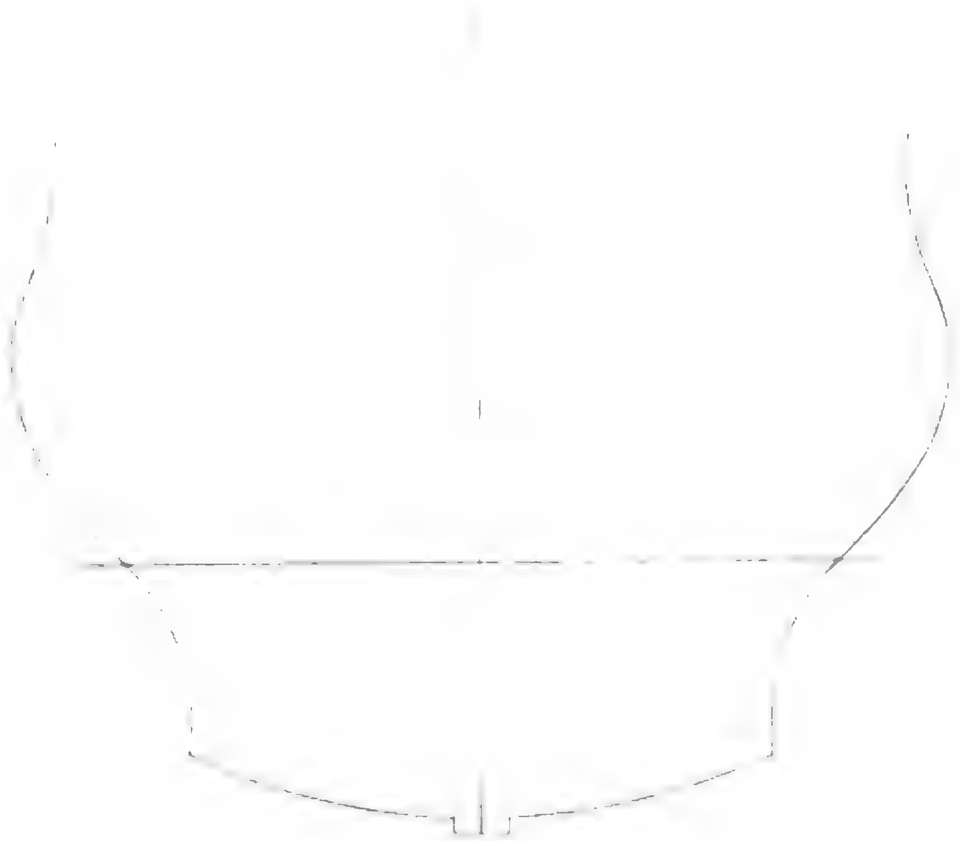


Fig 2. The Cornwallis



The dimensions of the *Transit* were as given below, and her form was as that shown in *Plate* 22 :

		Feet.	Ins.
Length on the deck		98	0
Breadth extreme		22	0
Breadth on the water line		19	0
Load draught of water	afore	11	6
	abaft	11	6

The rig of the *Transit* was not less peculiar than the form of her hull: she had four masts (as shown in *plate* 23), each receiving support from another, and her sails were so cut as to be well adapted to sail close-hauled. They were so formed as to present a great surface, whilst they could be reduced to a very small quantity. One of the greatest excellencies of this rig appears to have consisted in its simplicity, and in its being less encumbered with a multiplicity of ropes, &c.

The *Cornwallis*, a snow, built in the East Indies about this time, was likewise of a very novel construction, as may be seen by the form of her midship section (*fig.* 2, *plate* 24) ; and if full credit is to be given to the statements concerning this vessel, she had surpassed most vessels in her good qualities, especially as to her stability and speed.

The *Inspector*, from the peculiarity of her construction (see *fig*. 1, *plate* 24), appears to have been intended to have a weatherly quality; but if we may judge from the short time which this vessel was running, the design failed of its object. Her principal dimensions were as follow :

	Feet.	Ins.
Length on the upper deck	97	2
Breadth extreme	26	10
Depth in hold	13	3

Burthen in tons, 306.

The *Spanker*, floating battery, designed by Mr. Richard White, was one of those speculative and novel constructions which, as they relate to the interests of naval architecture, have been too often carried out without due consideration of the laws of floating bodies, and without reference to the principles which should determine both the form and capacity; and it is from vague notions, without a correct knowledge of principles, that failures in the construction of ships have so often resulted; and this was never more conspicuous than in the design of the *Spanker*, since not one of the objects for which she had been constructed was accomplished by her. This vessel was intended to be a formidable floating battery, to carry guns of large calibre and mortars, so as to be suited for offensive operations in bombardment, as well as for the defence of harbours. She was on the deck 111 feet 6 inches; and 42 feet 4 inches in breadth.

The main-deck was of an oblong shape, and square across at the bow and stern, so that four guns might be fired in lines parallel to the keel. This deck was made to project beyond the bottom, and was intended to be sufficiently high above the water, that when boats should go alongside to board, they might be drawn under the projection, in which scuttles were formed to fire through into them; but the ship had not enough displacement, and the projection was therefore brought too near the water for the boats to go beneath it. Under sail this vessel was unmanageable; hence she was soon kept for harbour service only at Sheerness.

As it regards the employment of the fleets of the British navy during the year, little need be said, as little was done by them. The enemy, whom they were stationed to blockade, cautiously avoided putting it into the power of either of the commanders of these fleets to do more than watch the general inactivity, in port, of the French fleets, which were constantly increasing by the addition of new ships; for though both at Toulon and in the Scheldt there were fleets of no inconsiderable force, yet they were restrained from making any such display of that force as would expose them to the contingency of an encounter with the fleets to whose vigilance they were subject. The Toulon fleet did sail on several occasions outside of the road; but such opportunities were taken for those exercises, as ensured the certainty of making a safe retreat within the harbour, before the English fleet could put them to any inconvenience. But although the French were able to make so little use of their navy, they were assiduous in increasing its force, by continually building large ships; particularly at the ports in the south of Europe. In the course of the year one ship of one hundred and thirty, and one of seventy-four guns were launched, and several ships were launched at the Italian ports.

Early in the month of March, however, a squadron of four ships of the line and two corvettes sailed from the port of L'Orient. These were soon discovered by a frigate, which was joined first by one and then by two ships of the line, when the attention of the British squadron was directed to that of the enemy; but no advantage was gained by the English from the proximity of the enemy's squadron; this was soon lost sight of, and afterwards cruised for nearly three weeks, during which time they made a few small prizes, and then returned to Brest, without meeting with any other British squadron during the cruise.

The relations of England became materially altered during the year, by the restoration of peace between herself and Sweden and the Russian empire; by a declaration of war between Russia and France; and by a similar declaration on the part of the United States against Great Britain.

The new declaration of war against France was material to England, as it engaged Napoleon in a remote expedition, which withdrew his attention, to a great extent, from England; and the disastrous result of that expedition is well known.

The French cruisers became still less active than they had previously been; but there occurred two encounters in the months of March and July, between portions of the Boulogne armament and British light cruisers.

On the first of these occasions, the English brig-sloops, *Rosario* and *Griffon*, attacked a squadron of twelve brigs, which were proceeding cautiously along the shore; and by very bold and persevering conduct, the British cruisers succeeded in getting possession of three of the enemy's brigs, in disabling one or two others, and in driving two more on shore. In the other encounter with a division of the flotilla, consisting of fourteen brigs, the British brig-sloop *Raven* drove three of them ashore, but did not succeed in making a single prize.

The only ship that was captured this year above the rate of a frigate was *the Rivoli*, of seventy-four guns. This ship had been built at Venice for the French navy; and at the time when she was taken, was nearly new. When this ship was known, or supposed, to be nearly ready for sea, the *Victorious*, of seventy-four guns, and the *Weasel*, an 18-gun brig-sloop, were sent to watch her motions. A very short time, however, before they arrived off the port of Venice, the *Rivoli* had sailed, and was accompanied by several brigs and other small craft. The British ship soon gained sight of the *Rivoli* and her companions. The *Weasel* engaged the *Mercure* brig, which, after the action had continued about forty minutes, blew up. This was between four and five o'clock in the morning, in the month of February. In the meantime the *Victorious* had begun the engagement with the *Rivoli*; but this ship was defended with such bravery and perseverance, that the action lasted four hours and a half, and during the latter part of this time the *Weasel* was engaged in support of the *Victorious*. Before the *Rivoli* surrendered, she was reduced to the condition of being able to use in her defence only two guns, and nearly half her men were killed or wounded. Both ships were in a very disabled state at the close of the engagement: the *Rivoli* had lost her mizen-mast, and the main-mast and fore-mast were so much injured, that they fell a few days afterwards.

For several months the two 40-gun French frigates *Andromaque* and *Arienne*, and the 16-gun corvette *Mamalouck*, had been at sea, committing extensive depredations upon British commerce, before they were met by any force to bring them to an engagement. The 74-gun ship *Northumberland* was at length detached to look after them, and on the 22nd of May she fell in with them, as she was cruising off the port of L'Orient. The object of the French was to escape, if possible, within that port; and to defeat that object, the *Northumberland* engaged them so near to the shore, that she became exposed to the fire of several batteries, as well as to that of the frigates. The frigates and the corvette, however, ran too near the shore, and grounded; and from this situation it was found they could not be removed. The only way, therefore, which remained to the English to dispose of these ships was, to cannonade them until they were destroyed; and preparations were made for the performance of this service in the afternoon. The *Growler* brig now arrived, and joined the *Northumberland* in the attack upon the grounded ships; and this attack was made so successfully, that both the frigates and the corvette were set on fire, and all of them exploded before the morning.

No ship of the line or frigate was captured, during the year, from any other power with which England was engaged in war. On one occasion, however, a Danish 40-gun frigate was destroyed. This was the *Nayaden*, which was seen in company with three brigs and some gun-boats, upon the coast of Norway, in the month of July. The British squadron consisted of the *Dictator*, of sixty-four guns, the brig-sloops *Calypso* and *Podargus*, and the gun-brig *Flamer*. The Danes retired into a creek, and were followed by the English. The navigable part of the creek was narrow, and one of the sloops took the ground; when the gun-brig was left to render her assistance, whilst the *Dictator* and the other sloop proceeded together to attack the Danish squadron. The result of the engagement was the destruction of the *Nayaden*, the capture of the three brigs, and the flight of the gun-boats; but in attempting to bring off two of the Danish brigs, they took the ground. In that situation a brisk fire was opened upon them from some gun-boats, so stationed that it could not be returned, which rendered it necessary to abandon the prizes; when they reverted to the possession of their late owners.

At the time when the United States of America declared war against England, they possessed several frigates of extraordinary dimensions and force. These became very formidable opponents to the British cruisers, which were stationed on the western side of the Atlantic. For, as they were far superior in both size and armament to British frigates generally, and were also very efficiently manned, the advantages in action were almost wholly on the side of the Americans. The first encounter a British ship had with any of these frigates, was that of the *Belvidera* frigate, when chased by an American squadron, and partially engaged by the *President*, in the month of June. On the 19th of August, the 38-gun frigate *Guerriére* came in sight of the American frigate *Constitution*, of the nominal force of forty, but in reality, mounting nearly sixty guns. Neither of the ships attempted to evade the other; and an action soon commenced, which resulted in the surrender of the English ship to her powerful antagonist. Towards the end of October, the *Macedonian*, 38-gun frigate, gained sight of the (nominally) 44-gun frigate *United States*, and chased her. An engagement ensued; and after the British frigate had been reduced to an entirely defenceless condition, she surrendered. A third engagement between the *Java*, formerly the French frigate *Renommée*, and the *Constitution*, led to a similar result. The British ship was reduced to an unmanageable and defenceless state by her powerful opponent, and then surrendered; but she was afterwards burnt by the American commodore. The *Alert*, 16-gun ship-sloop, was captured by the American 32-gun frigate *Essex*; and the *Frolic* 18-gun brig-sloop, by the American ship-sloop *Wasp*: but the

American sloop was taken, and the *Frolic* was recovered, on the same day, by the British 74-gun ship *Poictiers*.

Besides these, the British navy sustained the loss, in the course of the year, of one 38-gun frigate, the *Laurel*, the *Manilla* of thirty-six, and the *Barbadoes* of twenty-eight guns: one 16-gun ship-sloop, and two 16-gun brig-sloops, two 18-gun brig-sloops, four 12-gun brigs, one 10-gun cutter, and one fire ship, wrecked; one 16-gun brig-sloop, one 10-gun, and two 4-gun cutters, foundered; and one 12-gun brig, one 10-gun, and one 4-gun cutter captured: making a total number of twenty-six sail, of which, twenty-five were lost to the naval establishment. There were also four ships of the line, and twenty-eight frigates and smaller vessels sold or broken up during the year.

In 1812, there were launched thirteen 74-gun ships, one 40-gun frigate, five frigates of thirty-eight, and three of thirty-six guns; and thirty ships and vessels of inferior rates, including fifteen 18-gun brig-sloops, and ten gun-brigs of twelve guns. And the eight ships and vessels which were purchased into the service, rendered the additions to the navy, within the year, although not equal *in number* to the diminution, yet considerably superior to it in effect.

There were ordered, within the year, to be built, two ships of one hundred and twenty, two of one hundred and twelve, one of eighty, and six of seventy-four guns; five frigates of forty, fourteen of thirty-eight, and twelve of thirty-six guns, and thirty-nine ships and vessels of inferior classes: making a total of eighty-one ships and vessels; some of which, it appears, were launched before the expiration of the year.

At the commencement of the year 1813, there were one hundred and two ships of the line, and four hundred and sixty-eight ships and vessels under the line, in commission, as cruisers; forty-one of the line, and ten of the inferior classes, in commission for harbour duty; twenty-two of the line, and eighteen under the line in ordinary, for further service at sea; and fifty of the line, and ninety-eight under the line, not intended to be again commissioned for sea service.

The navy was but little reduced in its amount of force of shipping; but the number of seamen required for the service of the navy was reduced by five thousand; and the hundred and forty thousand seamen and marines were provided for at the rate of £4 2*s*. 9*d*. a man per month. The sum voted for the ordinary expenses of the navy, was £1,700,135; and the extraordinary expenses, including the building and repair of ships, and other extra work, were provided for by the sum of £2,822,031. The sum granted for the wear and tear of ships was £3,549,000. These sums, and others which were voted for the different parts of the naval establishment, amounted to £20,096,709. The ordinary, and particularly the extraordinary expenses, were materially increased.

The increase in the extraordinary expenses may be partially, if not wholly, accounted for by the alterations in some, and by the building of other ships with the view to encounter, under advantageous circumstances, the large and powerful frigates of the United States. It does not, however, appear that the building of any new frigates was essential to that service, for the frigates of the old *Leda's* class efficiently manned, and well provided, were capable of meeting them with confidence and success. And although the Americans, in the very limited number of ships of which their navy was composed, had aimed at an individual superiority in the construction and armament of their frigates, yet, the disparity of force by which they excelled the first class of English frigates, was such as the English had learned in their long experience to attach little importance to, when an intrepid officer commanded an efficient and well disciplined crew. The ships which were razeed in contemplation of being brought into action with these large frigates, were of superior force to them ; but it was still the policy of the admiralty to arm the ships above a just relation to their dimensions and tonnage; whilst they were too often inadequately manned, in comparison with the ships of both France and America. The smaller classes of cruisers which were intended to capture or destroy the American sloops, were subject to similar objections. The *Bonne-Citoyenne* was the pattern of a number of ships built about this time : but they were constructed with materially reduced dimensions of length and breadth, whilst a similar armament was appointed to them ; and the ships which were built after the form and proportions of the *Bonne-Citoyenne* were not to be compared with that fine vessel. Out of the eight ships which were built after this pattern and launched in 1813, the *Myrmidon* was the only one whose properties were not impaired by having the dimensions contracted. The *Bonne Citoyenne* was 120 feet 1 inch long on the gun-deck, 30 feet 11 inches in extreme breadth, 8 feet 7 inches deep in the hold, and measured 511 tons burthen. The *Myrmidon* measured 509 tons; and the seven others averaged about 460 tons. The consequences of the alterations which were made in this class of ships were such, that the expectations which had been formed of their capabilities, were greatly disappointed; whilst the cruisers of the United States were generally of the most excellent character, as to effectiveness and sailing.

The chief employment of the fleet commanded by sir Edward Pellew in the Mediterranean, was still that of watching the fleet lying at Toulon. This service was but little diversified by events throughout the year ; for, although the French fleet was decidedly superior to that of the English, yet no disposition was evinced to take advantage of that superiority. Divisions of the enemy's fleet were, however, occasionally sent out for the purpose of exercising the crews ; and, on one of these occasions, early in the month of November, a change in the wind enabled the English to approach sufficiently near to bring on a partial engagement. But this ended by the French ships effecting their retreat into the harbour of Toulon, before any result of consequence could be produced on either side. The French at this, and at their other naval depôts, continued to increase their fleets by the building of new ships; but the fine ships which were thus added to heighten the effective state of their navy, served but little purpose, as they were restrained by circumstances from making any use of their fleets.

Very few events of interest occurred, during the year, between the British and French cruisers. No French ship of the line appears to have been engaged by any British ship. The most distinguished frigate engagement was between the *Amelia* and the *Aréthuse* on the night of the 7th of February, in the Atlantic Ocean, near the coast of Africa. The action was not begun until the two ships were very near together; and little time then elapsed, before they were alongside of each other. This collision appears to have been accidental; but the close conflict which followed it, was maintained with a determined resolution on both sides. In addition to the cannonade, which was continued more than three hours, the French, who were more numerous than the English, used their small arms with very severe effect; but they were repulsed from boarding. Neither ship was reduced to the necessity of surrendering; the French, with musket and cutlass, had prevented the English from lashing the two frigates together; and in the calm state of the atmosphere which prevailed, the ships separated, and continued drifting in different directions, until they were beyond gun-shot of each other, when all firing ceased.

The memorable engagement of the *Shannon* with the *Chesapeake*, was fought on the 1st of June. The British frigate was stationed on the coast of North America; and the captain of her evinced a strong confidence in the capabilities of his ship and her crew, by sailing very near to the shore, and by challenging the American captain to meet him. The bold confident appearance of the *Shannon*, however, seems to have been sufficient; the *Chesapeake* was got under weigh; and both were eager to determine which ship should be the conqueror.

The action was not begun until the two frigates were near together. It then commenced, and was continued with great bravery for about ten or eleven minutes, when the frigates fell on board of each other, and an opportunity presented for boarding the *Chesapeake*, was seized at the critical moment. In this operation, Captain Broke led his men; and in less than five minutes after he had entered upon the deck of the *Chesapeake*, that ship became his prize. The result of this engagement raised the confidence of the English, and depressed that of the Americans, in respect of their frigate engagements.

Only three frigates were captured during the year, from both the French and the Americans. From the former, were taken the two 40-gun frigates *Weser* and *Trave*; and from the latter, the *Chesapeake*. Several national vessels of inferior rates were also captured; as were also a few privateers of considerable force.

The losses sustained by the British navy, consisted of one 74-gun ship, burnt by accident; one frigate of thirty-eight, and another of thirty-two guns, one 22-gun ship, two 18-gun ship-sloops, three 18-gun brig-sloops, and one of sixteen guns, two 12-gun brigs, one 10-gun cutter, and a store-ship, which were wrecked; two 10-gun brig-sloops and a 10-gun cutter which foundered; one 18-gun brig-sloop, one gun-brig of fourteen, and another of twelve guns; and one cutter of fourteen, and another of eight guns, which were captured; a 10-gun cutter, that was destroyed in action with a French privateer; and a gun-brig of twelve guns, that was destroyed by her crew to prevent her being captured.

To these losses, there was added the material reduction of one ship of ninety-eight, five of seventy-four, one of sixty-four, and one of sixty guns (the *Panther*, which was the last of that very inefficient old class of ships), seven frigates, and thirteen ships and vessels of inferior rates, sold or broken up, making twenty-eight sail; and six line-of-battle ships, and six frigates, were converted to other classes.

Four seventy-fours—the *Benbow*, *Blenheim*, *Cornwallis*, and *Vindictive*; three fifty-gun ships,—the *Jupiter*, of 1,173 tons, the *Leander* and *Newcastle* of 1572 and 1556 tons, were launched; the two latter, with the *Forth*, *Liffey*, and *Severn*, forty-gun frigates, were built of pitch-pine. Eleven frigates of thirty-eight, and eleven of thirty-six guns were also launched; eight of the former, and nine of the latter, were built of red pine. The average burthen of the 40-gun frigates was 1255, that of the thirty-eight's was 1077, and that of the thirty-sixes, was about 943½ tons. Nine sloops built on the reduced lines of the *Bonne-Citoyenne*, averaging about 460 tons, and the *Myrmidon*, built after the same pattern, of 509 tons, were launched during the year. Fifteen brig-sloops were built after the *Cruiser*, and launched within the year; the average burthen of these, was 386 tons: and eight gun-brigs, averaging 182½ tons, were likewise launched; with a few other ships of different classes. One 74-gun ship, three 50-gun ships, two frigates, twenty 20-gun ships, two 18-gun brig-sloops, and two bombs, were ordered to be built.

At the commencement of the year 1814, there were ninety-nine ships of the line, and four hundred and ninety-five ships and vessels under the line, in commission as cruisers. Thirty-nine of the line, and nine under the line, were in commission as guardships, &c., in harbours. Nineteen of the line, and twenty-four under the line, were in ordinary, suited for further service at sea; and forty-seven of the line, and one hundred and nine under the line, were lying in ordinary, not intended to be again commissioned as cruisers. Of the cruisers, as they stood at this time, fifty-two were of the middle class seventy-fours; forty-nine large class thirty-eights; forty-two small class thirty-sixes; thirty-three 18-gun ship-sloops with quarter-deck;

eighty-one large class 18-gun brig-sloops; thirty-two 16-gun brig-sloops; twenty-eight 10-gun brig-sloops; sixty-seven gun-brigs of twelve guns; and twenty-four 10-gun cutters: besides smaller numbers of almost every other class of ships and vessels of war.

With such a force as this, there was a complement of one hundred and eight thousand six hundred seamen, and thirty-one thousand four hundred marines voted to the naval service. But, with the prospect of a restoration of peace, this supply was limited to seven lunar months; and for the six remaining lunar months, there were voted seventy-four thousand seamen, and sixteen thousand marines. The maintenance and pay of these, were provided for at the rate of £4 5*s*. 9*d*. a man, per month. The sum of £1,730,840 was granted for the ordinary, and that of £2,086,274 for the extraordinary expenses of the navy. The sum of £3,268,000 was granted for the wear and tear of ships: and the entire amount of supplies for the naval service, exceeded the sum of £19,312,000 sterling.

The blockade of the port of Toulon was continued by vice-admiral sir Edward Pellew, who commanded a fleet consisting of two ships of one hundred and twenty guns, one of a hundred and twelve, one of a hundred, five of ninety-eight, and six of seventy-four; and a very limited number of light cruisers. This service constituted the principal employment of the British fleet in the Mediterranean. But, although the French had a fleet of six three-deckers, and sixteen two-decked line-of-battle ships lying in that port, they continued to maintain the same reserve with regard to the use of that fleet. No risk was run of a collision with any part of the British fleet, except to answer some particular end.

One event of this sort, did occur in the month of February. A ship, which had been built and recently launched at Genoa, was expected at Toulon, and had sailed for that port. With the view to her safe arrival, a squadron was sent out to meet her, and escort her to the place of her destination. The British fleet was cruising at some distance from the port, when the French squadron was seen at sea; and several ships immediately advanced to cut off the enemy's ships from returning into port. The French did not meet the new ship; and the English failed of cutting off the squadron from retreat. A very partial engagement occurred between the foremost of the English, and the rearmost of the French ships: but the new ship was not intercepted; and it arrived in safety at Toulon, a short time after the event had occurred.

In the Adriatic, the operations of the British cruisers were performed in connection with those of the army, or detachments of troops; and the result of those combined operations was, the surrender by the French of all the places of which they had had possession along the shores of that sea. Genoa was amongst the important places, of the possession of which the French were deprived during the spring. These events hastened on the crisis, which happily gave rest to Europe.

But, during the three months of this year, which preceded any negotiations for peace, the British and French cruisers had a number of sharp engagements, exceeding in proportion, what had been usual for a considerable length of time. The prizes which were obtained by these engagements, were the seven 40-gun frigates, *Alcméne, Cérès, Clorinde, Etoile, Iphigénie, Sultane,* and *Terpsichore;* and which became cruisers in the British navy,—most of them, however, under different names. And, at the taking of Genoa, on the 18th of April, the *Brilliant,* of seventy-four guns, was found ready for launching. She was, accordingly, launched and brought away by the English, in whose navy she was known afterwards as the *Genoa.* This ship was larger than it was customary to build ships of the same rate in England. Her length on the gun-deck, was 180 feet 7 inches; extreme breadth, 48 feet 6¾ inches; depth in hold, 21 feet 7 inches; proportion of breadth to length as 1 : 3.718; and burthen 1883 tons; and, unlike a number of ships of war which the French had built hastily, during the war, of green timber, this ship was built of good oak, and remained in the British service a considerable time.

Shortly after this, by the convention and treaty of Paris, peace was restored between all the allied powers and France; and England, after that event took place, had still America to contend with in war.

The events which occurred between the navies of Great Britain and the United States of America, from the beginning of the year, until nearly the close of it, when peace was restored, were, for, the most part, on a small scale: some of the most important operations being those carried on by means of boats up the rivers and creeks of that country. Only one American frigate was captured during the year; this was the *Essex,* which had been sent to cruise in the Pacific Ocean, where she had captured a number of British ships employed in the whale fishery. A prize which she had taken, was armed as a 20-gun ship, and called the *Essex Junior.* And early in February, these two were discovered at Valparaiso, by the 36-gun frigate *Phœbe,* and the 18-gun ship-sloop *Cherub,* which had been sent in search of them. The Americans became subject, on the arrival of these ships, to a confinement of about seven weeks in that port,—and were then captured. The *Essex* mounted forty-two guns, although she measured only 867 tons, having been built as long ago as 1798. The *Frolic,* afterwards named the *Florida,* an eighteen-gun ship-sloop, which was captured from the Americans, in April of this year, was very different in character from the *Essex.* This ship was superior to any of the same class in the British navy: she was 122 feet long on the gun-deck, 32 feet 4 inches in extreme breadth, 14 feet 3 inches deep in the hold, and measured 549 tons, and was only two years old. The American ship-sloops were generally fine vessels, well armed, and capable of engaging with considerable advantage the cruising sloops in the British service, these being of materially inferior dimensions.

The losses sustained by the British navy during the year, were confined entirely to the smaller classes of ships, the largest of which was the *Hermes* of twenty guns, which was destroyed whilst making an attack on an American battery. The *Avon*, an eighteen-gun brig-sloop, was also destroyed by the Americans: after having been reduced to a helpless condition, in an engagement with the *Wasp*, sloop of war, she surrendered. But, almost immediately after this, another British cruiser arrived sufficiently near to be a witness of the result which had been just determined, and went in chase of the *Wasp*; but was soon recalled to take out the crew of the *Avon*, which had been just accomplished, when the ship sank. Two brig-sloops of eighteen guns, and one of sixteen, one cutter of ten guns, and two of four, were captured by the Americans. Two brig-sloops of eighteen guns, one cutter of fourteen guns, one of ten, and one of six, and a troop-ship were wrecked: the latter was the *Leopard*, formerly a fifty-gun ship. Two ship-sloops, and one brig-sloop of eighteen guns, and one of sixteen,—two ten, and two four-gun cutters, foundered.

The war having at length closed, a great number of ships and vessels were sold or broken up. This reduction in the numerical amount of the navy consisted of one ship of eighty guns, ten of seventy-four, and eight of sixty-four; three 50-gun ships; six frigates of thirty-eight, eight of thirty-six, six of thirty-two, and three of twenty-eight guns; one 24 and four 20-gun ships; three ship-sloops of eighteen, seven of sixteen, and two of fourteen guns; two brig-sloops of eighteen, nineteen of sixteen, and one of fourteen guns; two gun-brigs of fourteen, and fourteen of twelve guns; and twelve cutters, &c., of different classes: making altogether nineteen ships of the line, and ninety-three ships and vessels of inferior rates.

The *Nelson* of one hundred and twenty guns, and four other line-of-battle-ships, one 50-gun ship, five frigates, fifteen 20-gun ships, two 18-gun brig-sloops, three 10-gun brig-sloops and one 8-gun bomb-vessel, were launched within the year; and one 74-gun ship, and one 38-gun frigate, were ordered to be built.

The real naval force of the country was also much diminished. The seven first-rates were put out of commission, as were three ships of the second, and forty-two of the third rate; and the number of cruisers under the line was reduced to three hundred and ninety-two, as the establishment stood at the commencement of the year 1815. There were then in ordinary sixty-two ships of the line, and fifty-three under the line: there were also lying in ordinary, not intended for further service at sea, seventy-one ships of the line, and a hundred and nine ships and vessels of inferior rates.

The naval supplies for the year provided for the maintenance of seventy thousand seamen and marines for the first three months, and ninety thousand for the remaining ten lunar months, at the rate of £4 5*s*. 9*d*. a man per month. The sum voted for the ordinary expenses of the navy, was £2,278,929; and that for the extraordinary expenses, was £2,116,710.

The excess of these two items over the corresponding sums in the preceding year's estimates, was about £578,524. The sum for the wear and tear of ships, was £2,386,500; and other expenses added to these, made the navy estimates for the year amount to the sum of £17,032,700; and to this was added the sum of £2,000,000 sterling, towards paying off the debt which had been contracted in carrying on the great naval operations of the war.

Although the treaty of peace between Great Britian and the United States of America was signed in Europe on the 14th of December, 1814, yet, as that fact was unknown in America until some time afterwards, the cruisers of the two countries continued their services with their customary activity. In the month of January, the violence of the weather drove a British squadron, which had been stationed on the coast of America, from the position which it had occupied; and allowed the *President*, one of the large American frigates, and a brig, to put to sea together. The *President* had not been long, however, at sea, before she was fallen in with by two of the British cruisers, the *Majestic*, a razée, and the *Endymion* frigate, which chased the *President*; and in a few hours the *Endymion* began to fire upon her, and a sharp engagement followed, until the British frigate's rigging and sails were so much damaged, that it was necessary to bend new sails. Whilst this service detained the *Endymion*, the enemy, which was supposed to have surrendered, endeavoured to escape, but was met by the *Pomone* frigate, from which she received two or three broadsides, to which the reply was, that the ship had surrendered. Before possession was taken, the *Tenedos* frigate arrived also, and received the same information from the American. Each of these frigates had sent a boat to take possession of the prize before the *Endymion* could do so, although this frigate had fairly beaten the American. The *President* was superior to the *Endymion* by 256 tons in burthen, by eight guns in armament, and in her crew, by nearly one hundred and fifty men. The armament of the *President* was also of larger calibre than that of the British frigate.

A few small British cruisers fell into the hands of the Americans before hostilities terminated. The *Constitution*, a large frigate, was now one of the most active cruisers belonging to the United States; and in the month of February she captured the 22-gun ship *Cyane*, and the *Levant* sloop, mounting twenty guns. This ship and her two prizes were fallen in with a short time afterwards, at the Cape de Verd islands, by the British frigates *Leander*, *Newcastle*, and *Acasta*. On the approach of the English, the American frigates and her companions sailed, endeavouring to avoid a meeting. The frigates chased them: but with no greater advantage than the recovery of the *Levant*, after that ship had taken refuge in a Portuguese port, presuming that the neutrality of the place would insure security. The *Constitution* escaped by virtue of her sailing qualities, as she had done twice before, in the years 1812 and 1814.

THE HOWE OF 120 GUNS.
Launched in the Reign of Geo. III. during the Regency.

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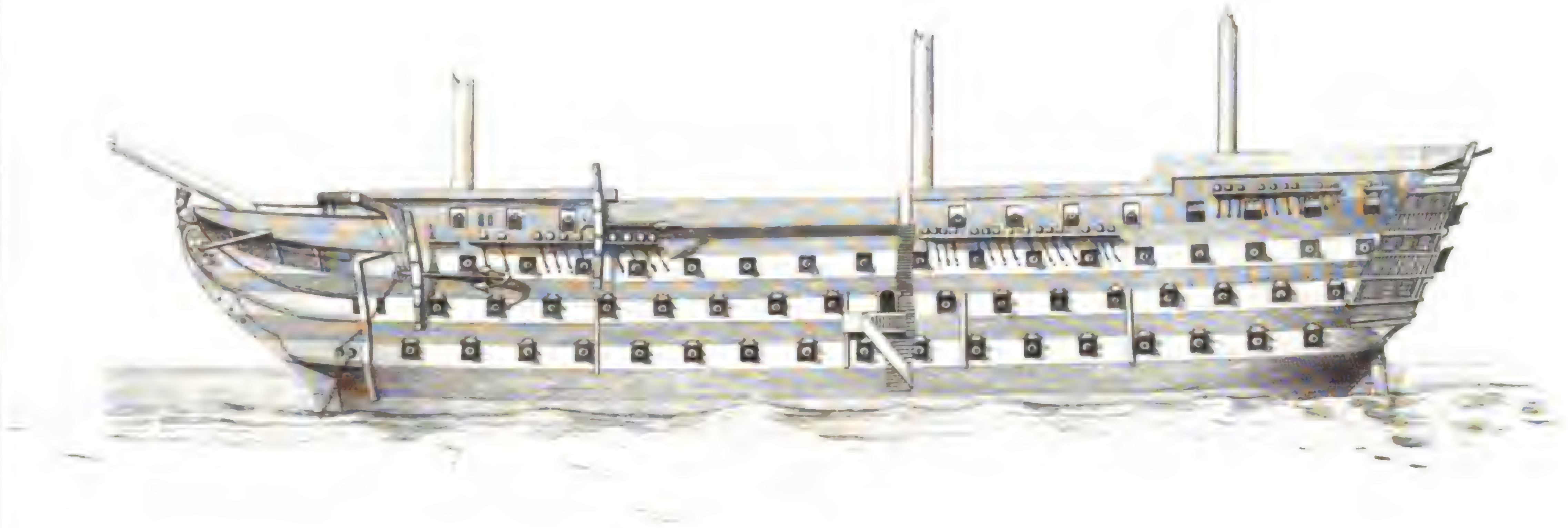


The return of Buonaparte from Elba occasioned a renewal of hostilities between England and France; and one of the measures taken by the British government for hastening the new war to a crisis, was the sending of a fleet, under the command of lord Exmouth (formerly sir Edward Pellew), into the Mediterranean. It was not, however, possible for Napoleon to render it a naval war with any prospect of success. His great resources were military, and the events of that day which witnessed the last defeat of that great commander, need not be related here. Buonaparte was desirous, after that final triumph of the English, to retire to the United States of America; but he found no opportunity of eluding so effectually the vigilance of the English as to be able to do so, and in that hopeless prospect he surrendered himself, on the 15th of July, to captain Frederick L. Maitland, commanding the 74-gun ship *Bellerophon,* which was lying in the Basque roads. He was immediately conveyed to England; and, on the 8th of August, the *Northumberland* sailed with him for St. Helena, the place of his banishment, where he was landed about the middle of October.

But before the contest between England and France was brought to a close, a few naval events occurred. One of these was the capture of the *Melpomène,* 40-gun frigate, by the *Rivoli.* This frigate had been built at Toulon, in 1813, and measured 1087 tons. Her principal dimensions were 152 feet 10½ inches in length on the gun-deck, 40 feet 1¼ inch in extreme breadth, 12 feet 6½ inches deep in the hold, and the length was 3·82 times the breadth. No other ship of war or frigate was captured from the French during the short period of renewed hostilities.

Peace was, in effect, restored by the surrender of Napoleon; and it was confirmed by the treaty which was signed at Paris on the 20th of November following. England retained very little of the territory which had been taken from France during the war; but the peace was established upon a more stable basis than it had been at the commencement of the century.

With the prospect of a well-established peace, the naval establishment was greatly reduced. Sixteen ships of the line, and seventy-five under the line, were sold out of the service or broken up: one of these was the *Salvador del Mundo,* of one hundred and ten guns, which had been taken from the Spaniards in 1797, and measured 2398 tons. Eight ships of the line, and thirteen under the line, underwent alterations which reduced them to other classes. There were wrecked one 38-gun frigate, one 18 and one 16-gun ship-sloop, a 14-gun cutter, and a troop-ship. One ship of twenty-two and one of twenty guns, an 18-gun brig-sloop, and a 12-gun cutter, were captured by the Americans: the capture of the two ships, and the recapture of one of them, the *Levant,* have been already mentioned.

The ships launched during the year were eight of the line, the *Howe* and *St. Vincent* of one hundred and twenty guns, the *Cambridge* of eighty, and the *Defence, Hercules, Hero, Redoubtable,* and *Wellesley,* of seventy-four, and nine of inferior rates, amongst which were the *Java, Isis,* and *Romney.*

By the beginning of the year 1816, the naval establishment was so far reduced, that there were only thirty ships of the line, and two hundred and three ships and vessels under the line, in commission as cruisers: three ships of the line, and two of inferior rates, in commission at the several ports. Seventy ships of the line,—which were eight of the first rate, six of the second rate, and fifty-six of the third rate,—and one hundred and thirty-four ships and vessels, from the fourth rate down to cutters, were in ordinary, eligible for further service at sea. There was also the same number of ships and vessels in ordinary for harbour service, &c. At this time the proportions of foreign-built ships in the British navy were one-ninth of the line-of-battle-ships; and very nearly one-eighth of the inferior classes were at sea or suited for further service at sea; and of those which were fit only for harbour service, there were twenty-three out of the seventy-three line-of-battle-ships, and thirty-nine out of the hundred and thirty-six ships and vessels under the line, of foreign build. None of the unfinished ships on the stocks are taken into these statements.

In the reduction to which the naval establishment had been subjected since the restoration of peace, thirty-three thousand seamen and marines were deemed sufficient for the year; and these were provided for at the rate of £4 5*s.* 9*d.* a man per month. The sum voted for the ordinary expenses of the navy was £2,689,931 18*s.*, and that for the extraordinary expenses was £2,102,563: these, and the various other expenses of the navy, and of the establishments and services connected with it, amounted to £10,114,345.

The British navy still continued to be diminished by the breaking up, and otherwise disposing of, a considerable number of old ships, a reduction which was very desirable after the long and arduous services which had tried its energies for so many years; for reduction, under such cirumstances, contributes to improvement, when establishments have grown beyond the limits of ample capability and usefulness.

Nothing occurred to call into hostile exertion the powers of the British navy until the summer. At length, the piratical depredations and the cruelty of the Algerines grew to such a height, that it was deemed necessary to send out an expedition capable of inflicting so severe a chastisement upon the city of Algiers, as to ensure obtaining from the Dey the ends of justice on behalf of European commerce, and the release from captivity of Europeans who had been taken by the pirates, and consigned to slavery.

When the course of retribution was resolved upon by the British government, admiral lord Exmouth was appointed to command the fleet which should execute it; and the fleet which was fitted out on the occasion, consisted of the *Queen Charlotte* of one hundred guns, the *Impregnable* of ninety-eight, three ships of seventy-four guns and one of fifty, two 40 and two 36-gun frigates, two 18 and three 10-gun brig-sloops, four bombs, and two or three other vessels for particular services connected with the expedition. This fleet sailed from Plymouth about the end of July, and in twelve days afterwards anchored in the bay of Gibraltar. Here lord Exmouth accepted the offered service of a Dutch squadron, consisting of four 40 and one 30-gun frigates, and an 18-gun corvette, to co-operate in the attack on Algiers.

On the 14th of August, the combined British and Dutch fleet set sail from Gibraltar, having made all the necessary preparations, and taken several gun-boats and flat-bottomed boats to be employed in that service. The fleet did not, however, come within sight of the city of Algiers until the morning of the 27th; and on the forenoon of that day a flag of truce was sent, proposing conditions to the Dey, and requiring an answer within a limited time. The reply did not arrive within this time; and it was hence concluded that he would not accede to the terms. The fleet proceeded therefore to carry into effect the extreme measures for which it was prepared; and at a few minutes after half-past two o'clock, the admiral's ship came to anchor within a very short distance of the mole-head; and the other ships anchored as soon as they could arrive at the stations to which they had been appointed.

The action was begun by the firing of a few shot from the Algerine fortifications, which were very strong and extensive, and mounted with a very large number of cannon. The *Queen Charlotte* quickly returned the fire of the batteries with a most destructive effect; for three broadsides from that ship destroyed the part of the fortifications against which they were directed; and immediately the same vigorous and effective fire was turned against another part of the batteries, which was soon likewise wholly disabled. A heavy fire was also kept up by the Algerines; and several of the ships sustained considerable loss; but still they maintained their destructive fire till about ten o'clock at night. The fire from the batteries had nearly ceased by that time; and the admiral withdrew his ships, for the night, beyond the reach of the feeble fire that was yet kept up from the shore. During the time that the ships of war were cannonading the fortifications, the four bomb-vessels threw, it is stated in the narrative of this expedition, nearly a thousand shells; many of which falling upon the fortifications and the city, set fire to it in several parts: and others falling upon the ships and vessels in the harbour, produced amongst them a general conflagration, which was communicated to the arsenal and storehouses. A frigate which was moored across the mole was set on fire by boats which were sent from the *Queen Charlotte* for that purpose, and was destroyed.

On the following day, a flag of truce was sent with a repetition of the demands which had been made on the arrival of the fleet. And, after the very extensive injury which the action had inflicted, there was little difficulty in obtaining concessions to all the requirements that were made.

These were the unconditional release of all christian slaves, and an engagement to abolish the practice of enslaving Europeans; the repayment of 382,500 dollars which had been paid by Naples and Sicily for the redemption from slavery of natives of those States; the payment of 30,000 dollars to the British consul for the destruction of his property; a public apology to him for the indignity with which he had been treated; and peace with the king of the Netherlands. The expedition gained the release of more than twelve hundred Europeans, who had, at different periods, been consigned to slavery in its most degraded forms. But none of them were British subjects.

Perhaps few expeditions that have ever been undertaken, have been calculated to gain greater respect for the British navy than this was. The object of it was humanity, unrestricted by any influence of nationality; and the complete success of it affected several continental kingdoms more immediately than it did the country which had sent it out.

From the time of completing the service which has just been noticed until the close of the year, no other event called for any similar exertion of power; and the universal peace which now prevailed, allowed a further reduction to be made in the naval establishment. Twenty-two ships of the line, and ninety-one of inferior rates, were sold, broken up, &c., during the year; and two frigates, a 20-gun ship-sloop, two 10-gun brig-sloops, and a 14-gun cutter were wrecked. Forty-five ships of the line, and ninety ships and vessels under the line were converted to other classes. As there were but few ships launched during the year, the reduction was almost entire.

At the commencement of the year 1817, there were only fourteen line-of-battle ships and a hundred ships and vessels of inferior classes in commission; two hundred and sixty-three, deemed fit for further service at sea, were lying in ordinary; eighty-four of which were of the line. Forty ships of the line, and sixty-four of inferior rates were in ordinary, deemed unfit to be put again in commission.

Thirteen thousand seamen and six thousand marines were voted for the service of the year 1817, at a reduced allowance of £3 19*s.* a man per month, amounting to £975,650, for their annual maintenance. The sum of £2,476,150 was voted for the ordinary expenses of the navy; and the sum of £1,391,645, for the extraordinary expenses. These and other items of expenses for the year, amounted to the sum of £5,985,422; and to this was added £1,660,000 sterling, in liquidation of the navy debt.

From the time that carronades were extensively introduced into the naval service of England, until after the close of the war, that description of armament was not classed with the other ordnance; but it constituted rather a supplementary armament to the ship. Hence, there was a general discrepance between the nominal and the real force of those ships which were partially armed with carronades; and as the use of these had become general, so the general rating of ships of war was fallacious to the extent to which carronades were used; and it was deemed by the board of admiralty important to the naval establishment, and to the country to which it belonged, that that practice should be discontinued, and the ratings made to accord with the amount of armament borne by each class of ships. With this view, a memorial was presented to the Prince regent, recommending that the old classification of ships should be revived and established; and that in future all his Majesty's ships should be rated at the number of guns and carronades which they actually carry on their decks, quarter-decks, and fore-castles. An order in council was accordingly made in February 1817, establishing the plan of classification which had been submitted.

The revision which was thus made in the ratings of ships did not wholly rectify the statements of force throughout the navy; but it brought the nominal rates of the different classes of ships much nearer to their actual armament than they had previously been.

For many years the system of ship-building was obviously defective, inasmuch as the ships were not strong enough to bear the strains they were subject to in a heavy sea, but were constantly working. When the parts of a ship had yielded under these strains, additional iron knees, standards on the deck, or in some cases a few riders to the topsides and in the hold, were used; or some other similarly ineffectual means were resorted to, to repair her strength. The advantage of these was merely temporary; they served to strengthen the ship until she was again subject to heavy strains, and then her essential weakness was again apparent; and, as the service of blockading and other duties in the long war required the ships to keep the sea as long as it was practicable, there were so many instances of this weakness as to show that it was not the result of anything *accidental* in the building of them.

This weakness had been very long the subject of complaint, as it impaired materially the comfort of the crews in the protracted services of blockading and cruising; and still there was a desideratum of adequate means as a remedy. There was a *system* of building; and this had been so long established, and had received the sanction of so many officers who had reached the head of their profession, that it might require the effort of more than an ordinary mind to make, at once, an effectual inroad into it, in the introduction of improvement. But the numerous instances in which complaints of weakness had been verified, and the difficulty of obtaining knee timber for connecting the beams with the sides of the ship, (*Plate* 25, *fig.* 1) having been long felt, prepared the way for a great innovation; and the merit of making this innovation belonged to sir Robert Seppings. This merit is quite irrespective of the value of his plans, about which differences of opinion prevail. The innovation into established usage was valuable, as it destroyed the force of those prescriptive restraints which had been so long and so much respected; as the venerated standing which the old system had obtained led each successive age of shipwrights to overlook its imperfections, whilst they could add such means of strengthening as those which have just been mentioned.

The evidence of weakness, however, forced itself upon the attention of ship-builders; it could not be disputed that ships were not built strong enough for the service; and the best shipwrights acknowledged the necessity of some grand alteration, long before the sanction of established usage became too little respected to maintain that usage.

The same defectiveness in the strength had engaged the attention of the French; and Duhamel states, in his Architecture Navale, that about the middle of the last century, a proposal was made to cross the ceiling of ships with oblique iron riders. Chambot, a French naval engineer, repeated the proposal to substitute oblique for common riders; and these were commonly used to strengthen both the topsides and holds of our ships during the last war.

In 1772, Clairon des Lauriers, a French engineer, introduced into *L'Oiseau*, frigate, diagonal panels, which were formed by the planking and pieces laid in a diagonal direction: this frigate was captured by the English in 1779. Bouguer speaks, in his Traité du Navire, which was published in 1746, of a M. Gobert laying the ceiling diagonally to prevent the ship from arching. The French 74-gun ship *Jupiter*, which was captured by the English in 1806, had eight vertical riders in the hold; the foremost one was 25 feet from the bow, and the after one was 45 feet from the stern. The ceiling was laid with proper sheer as high as the floor-heads, as was also the planking before the foremost, and abaft the aftermost riders; and between the riders from the floor head to the orlop shelf, it was laid diagonally. But this plan did not answer its object; for when the ship was in the British navy, named the *Maida*, she was found to arch as much as any ship in the service. The *San Juan Nepomuceno*, which was built at Ferrol in 1781, and taken by the British in 1805, had diagonal riders in the hold over the ceiling. The *Pobedonossetz* of sixty-four guns, which was constructed by M. Brun, the chief engineer in the Russian service, and built in Russia in 1809, had the riders in the hold inclined to an angle of about 45°; the breadth and top riders were likewise laid diagonally, but inclining in a contrary direction. The beams of this ship were fastened to the sides by means of dagger-knees, which in many cases abutted against the riders.

These instances may be sufficient to show how general that weakness was from which ships broke their sheer; and as the defectiveness of construction and combination was general, so there were in most maritime countries some means employed with the view to prevent their arching. These means consisted generally in placing some of the timbers diagonally; but they were always proved on trial to be insufficient for the purpose. The

IMPROVEMENTS PROPOSED BY Mr ROBERTS AND SIR R. SEPPINGS.

Fig. 6

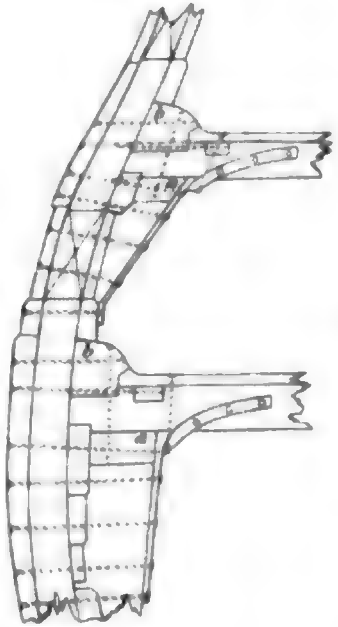


Fig. 1.

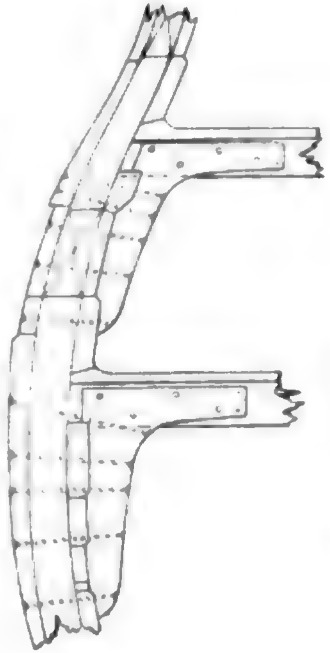


Fig. 2.

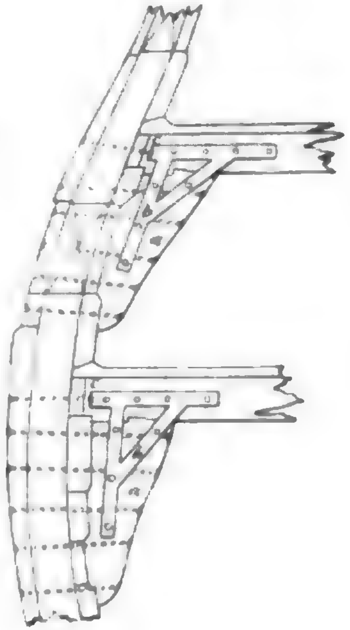


Fig. 4.

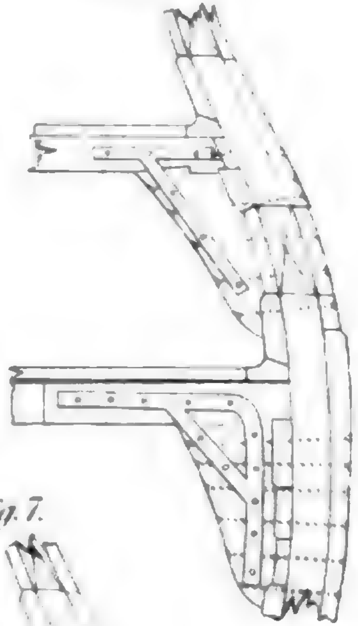


Fig. 5

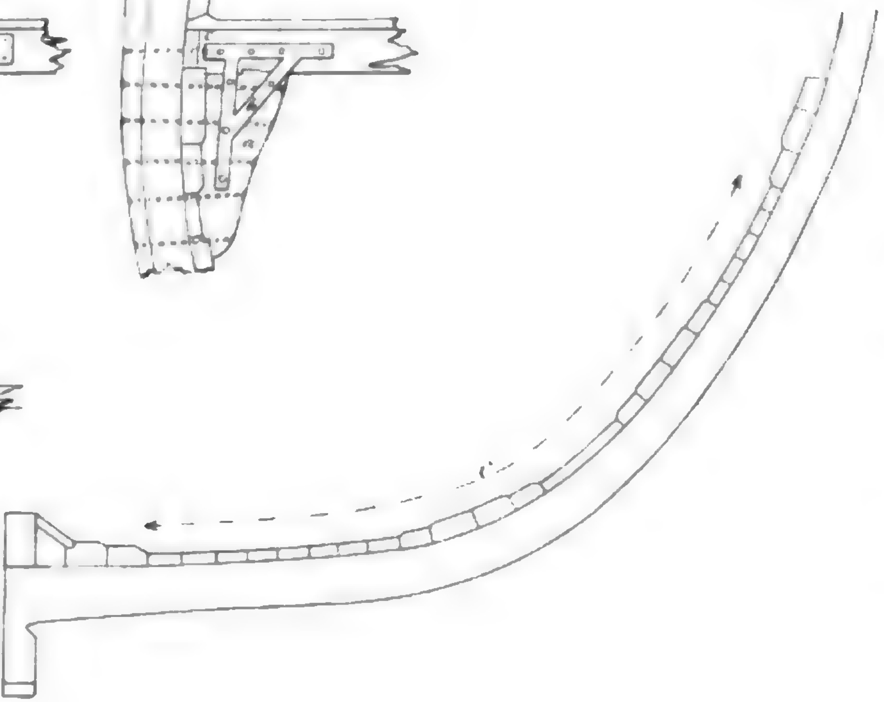


Fig. 7.

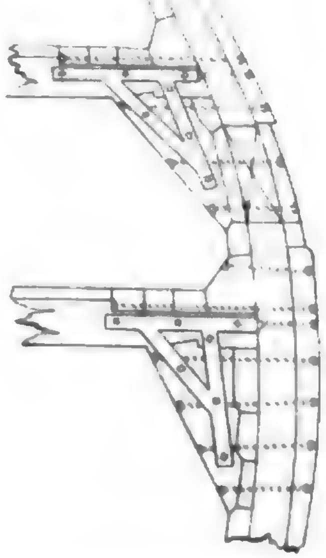
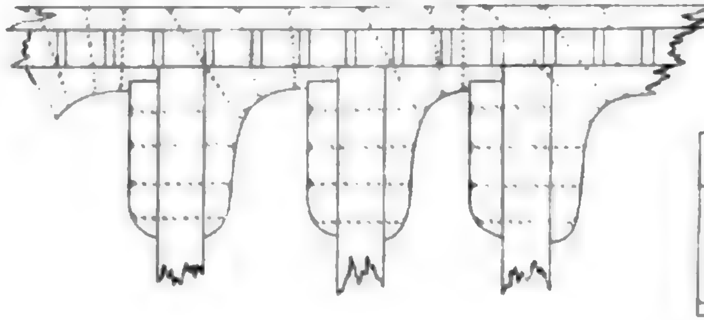


Fig. 3.



want of adaptation in these means lead us to infer, that it had not yet been considered how the forces which produce arching act upon the structure generally; for, when the effects are very great in these cases, and they are carefully observed, it is perceived that a compression must take place in the lower part, or an extension in the upper part of the ship, or extension and compression together; and it is evident then, that any means which should have sufficient power to prevent a ship from arching, must be such as to increase directly and in a great degree the longitudinal strength of the upper part, whilst the lower part should have sufficient solidity, that it would not yield to the forces acting to produce compression. These conditions of the structure were at length perceived by sir Robert Seppings; and the system of building which he introduced was suited to them, as it gave the degree of longitudinal strength and firmness which was required; and although it may not now be fully acted on, yet the alterations which have been subsequently brought into use are only modifications of parts of that system.

Whilst we justly give to sir Robert Seppings the credit of having broken down the barrier to improvement by introducing a grand deviation from the old methods of forming and combining the fabric of a ship, it is also just to say that Mr. Roberts, one of the sub-surveyors of the navy, had previously proposed a new mode of connecting the beams with the sides of the ship by means of a chock *a*, under the beam, (*Plate* 25, *fig*. 2) and a side-plate *b*, on each side of the chock opposite to each other, fastened with bolts which passed through the sides and through the chock and the two plates, and the beam and the two plates respectively. These plates had an arm, *c*, which turned against the side, forming a good substitute for the lodging-knee in the old system, which was used for uniting the beams to the side, (*fig*. 3.) This method of securing the beam-ends to the sides appears to have been a combination upon which the labouring of the ship in a sea produced but little effect, so far as impairing the compactness; and even now, after having been employed a number of years in sea service, this combination still remains firm in some of the old ships. The combination proposed by Mr. Roberts could, however, present no claim to being considered complete in itself; each connection with the side embraced only one beam, and one or two of the timbers of the frame, and did not therefore contribute to the longitudinal strength of the ship, nor was it a continuous combination. It is also proper to state, that some time before Mr. Roberts brought forward his plan, there had been introduced in other nations a similar method of combination, as it regards the iron plates. (*fig*. 4.) Several other plans followed that of Mr. Roberts, for connecting the beams with the sides; but as they were not brought into general use, it is not necessary to notice them further.

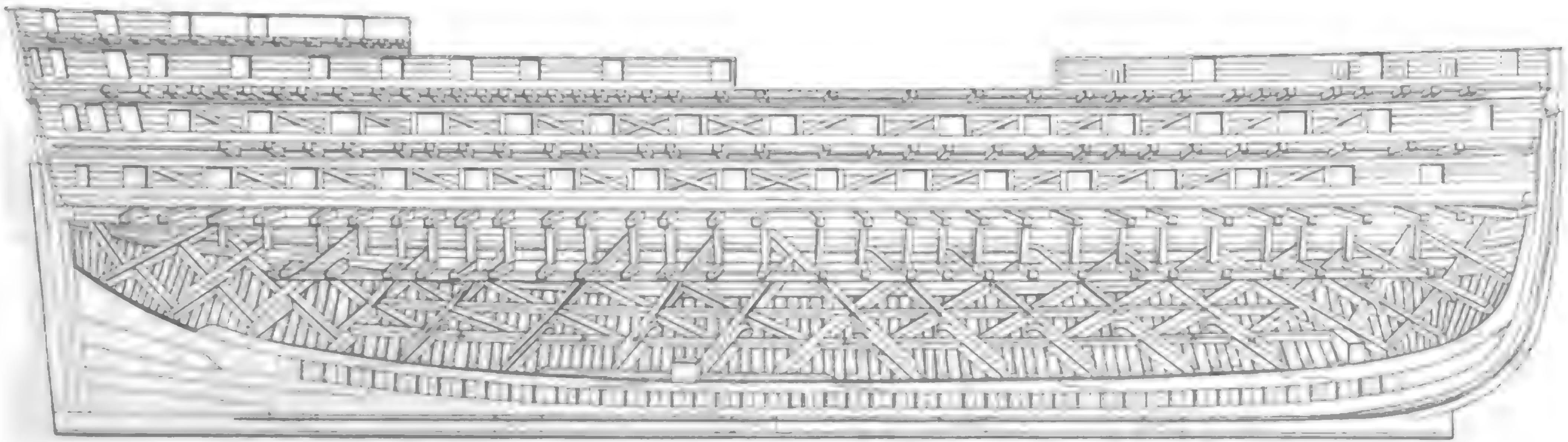
The plans which were introduced into the art of ship-building by sir Robert Seppings included an almost entirely new system of combination throughout the structure, but they were brought gradually into use. Th principal parts in his system may be stated briefly in the following order: first, the filling in of the openings between the timbers of the frame, and the leaving out of the interior planking below the orlop clamps; secondly, the trussed frame; thirdly, the connection of the beams with the sides by means of the shelf-pieces, thick waterways, and side binding-strakes to the deck; and fourthly, the laying of the decks diagonally. In the month of February, 1806, it was ordered that the second and third parts of this system should be tried on the first 74-gun ship and frigate that should be built, and that the footwaling or ceiling (*c, fig.* 5) should be discontinued; in May, 1810, the first part, in connection with the diagonal riders, was ordered to be applied in the repairs of the *Tremendous;* and in November, 1811, the fourth part, in connection with the thick waterways, was ordered to be applied to the *Ramillies* and *Albion*, ships of 74 guns. In the year last mentioned, it was ordered also that ships should be built with the bows round all the way up, instead of their having beak-heads, as shown in the plate; and likewise that ships should have round or circular sterns; but these will be noticed separately. There were other points of alteration of minor importance which he introduced, but these constitute rather a part of the general plan than distinct alterations in the system of ship-building.

First, the filling in of the openings between the timbers of the frame was not altogether an original part of the system; for, some time before sir Robert Seppings brought forward his plan, the openings had been filled in to the floor-heads, with the view to render the part of the frame from the floor-heads downwards one mass of timber, that it might be the better able to bear the shock of striking, and the strain of lying upon the ground: and also, in the event of the keel being knocked off, to prevent the influx of water into the ship, especially when a strake, as is sometimes the case, in the fore and after bodies, is bolted firmly to the timbers, and caulked between the plank and timber, to prevent the passage of water between the two surfaces; and as long ago as 1763, Mr. Thomas Kirby, of Chatham-yard, proposed, with a view to the security of the ship, and to her preservation by excluding impure air from the openings, that the spaces between the timbers from the line of flotation downwards should be filled in and caulked both inside and outside.

The filling which was brought into use bysir Robert Seppings extended, in large ships, from the middle line of the ship to within 4 inches of the lower side of the planks under the orlop-shelf; and, in smaller vessels, to within 4 or 6 inches of the plank under the lower-deck shelf, or strake under it, if there was one. From 1810, when fillings were first ordered to be used, until July 1816, they were of the same breadth as the timber; when the openings were not less than 3 inches, the range of fibre was placed in the same direction as the timber, but when they were less, the

SIR ROBERT SEPPINGS'S TRUSSED FRAME.

Line-of-Battle Ship



fillings were wedge-like, and were driven from inside and outside with the grain or fibre crossing that of the timbers; and in both cases the fillings were caulked on the same edge for the oakum to meet, and chinsed or slightly caulked on the opposite edge. In September 1817, the openings were ordered to be filled in on the outside with seasoned oak 3 inches thick, which was to be well caulked on one edge and chinsed on the other; and roman cement was to be placed in the opening to within 2½ inches of the inner surface of the frame, and the space from the cement to the inner part of the timber was filled with 2½-inch oak, one edge of which was caulked and the other chinsed.

The filling in with roman cement, when it was mixed with water, was found sometimes to produce decay in the timbers, but in all cases in which it had been mixed with either vegetable or coal tar the timbers were preserved. When the openings were very small they were filled in with wood, and caulked as others; and in all cases a mixture of oil and tar was injected, to fill up any interstices which might remain. But the great quantity of mineral tar which was used for this purpose, soon after this system of building was introduced, became very offensive by its odour, and it was considered by some to be injurious to the crew, as it was to some of the provisions; it was therefore discontinued. As a substitute for tar, a mixture of oil and whiting was introduced into the interstices; and this, together with the housing over ships whilst they are being built and repaired, has doubtless contributed much to their durability.

There is no doubt that the fillings increased the longitudinal strength of the ship; for, before the body can deflect, or, as it is called, break her sheer, a compression must take place below and an extension above. Now, as the timbers of the frame and the fillings constitute a solid mass, and are as incompressible as the nature of the substances of which they are composed will admit, the resistance to arching or bending is increased by the solidity.

The *second* part of the alterations introduced by sir Robert Seppings was the *trussed frame*. This was a combination of timber brought into contact with the frame of the ship, where the ceiling or interior planking below had been placed. (*Plate* 26.) It consisted of a frame which was composed of timbers or riders, *a*, longitudinal pieces, *b*, and trusses, *c*. The principal parts of this frame, which are called the riders, timbers, or braces, *a*, are commonly in three lengths, and extend from the limber strake to about 6 inches below the gun-deck shelf. The timbers are placed at an angle of about 45° with a vertical transverse plane. They incline forward in the after body, and aft in the fore body, so that they resist the arching by extension. The longitudinal pieces (*b*) are brought immediately over the heads and heels of the frame of the ship, with their abutments fitting closely between the riders or diagonal timbers (*a*). The trusses (*c*) are placed on the diagonal of the rhomboid, formed by the timbers and the longitudinal pieces, and abut firmly against both. The whole of this frame is well bolted through the timbers of the frame and the outside planking.

As it is difficult to give to the fabric of a ship that degree of stiffness which will be always sufficient effectually to resist its tendency to arching, or sinking at the extremities, it is important that the distribution of the materials should be such that an effectual combination may be made with the different assemblages, so as to give a general support; and that there should be such a disposition as not to cause a separation, opening, or working of the several parts of the structure when the body is arched or bent; but that as soon as the stresses are removed, it may recover itself by its own elastic force. The component parts of the trussed frame are well disposed for obtaining this result,—more especially in the upright part of the side of the ship; whilst the part which comes in the bilge of the ship can yield but little support to resist longitudinal bending.

When a strain is brought upon a ship tending to produce a bending or arching, the trusses and longitudinal pieces are acted upon by being compressed; this compression has a tendency to force the body out by the strength of the fibres; but as the riders or braces sustain the whole pressure, they resist it by being brought into a state of extension, and give their support by the strength of their fastenings. The whole frame is therefore acted upon, and each part of it offers its appropriate resistance to any alteration being produced in the form of the body, which cannot bend except as the materials and workmanship are imperfect. (*See Philosophical Transactions of* 1814, *Part* II., *p.* 301.)

The trussed frame was not applied by sir Robert Seppings to large frigates, but instead of it there is a combination of thick strakes (*a, Plate* 27), and iron plates or riders, *b*, the latter being worked over the strakes. The thick strakes are brought immediately over the joints of the timbers, and lie in such a direction over the inside of the frame as to take nearly their shortest distance over the inner surface of the frame of the ship longitudinally. Two of these strakes are combined together, one pair over the floor and the other pair over the first futtock-heads, and the iron riders are placed over these strakes. These riders extend from four inches below the lower deck shelf, and receive two bolts below the floor-head; they are generally about 1¼-inch thick and 6 inches wide, and they are placed at about the same inclination as the timbers in the trussed frame, with the upper part inclining forward in the fore body, and aft in the after body. They are in two lengths, joined by a scarph about 6 feet long, and lie side by side, crossing the first head; at the upper end they are about 5 feet apart, lying on the inside plank; and at the lower end they are brought under the planking, that is, between the timber and thick strakes on the floor and first futtock-heads. This system might be improved by having several pairs of longitudinal binders, or thick strakes, *a*, and iron riders lying over their inner surface, (*b, Plate* 28); it would then form a combination which would

SIR ROBERT SEPPINGS'S IRON RIDER PLATES.

Plate 57.

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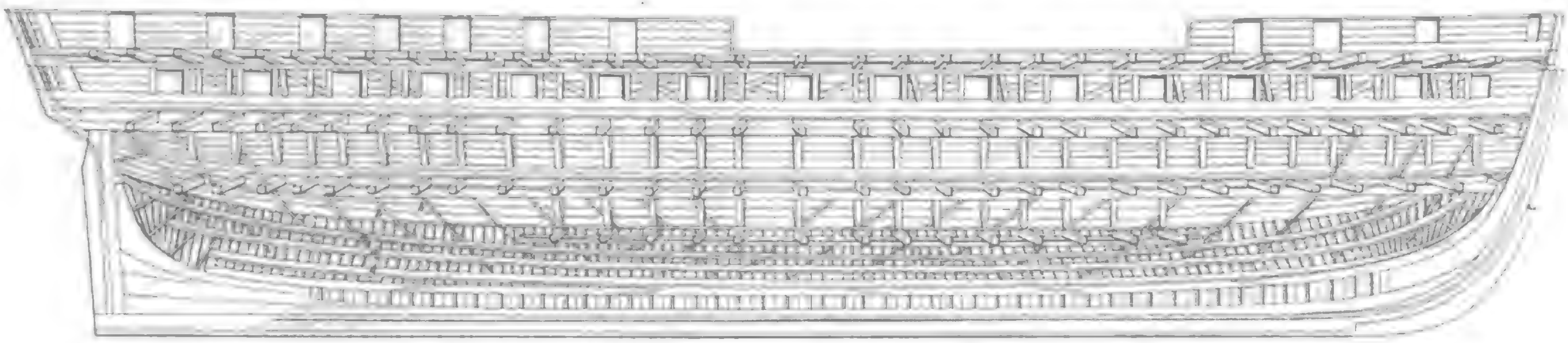
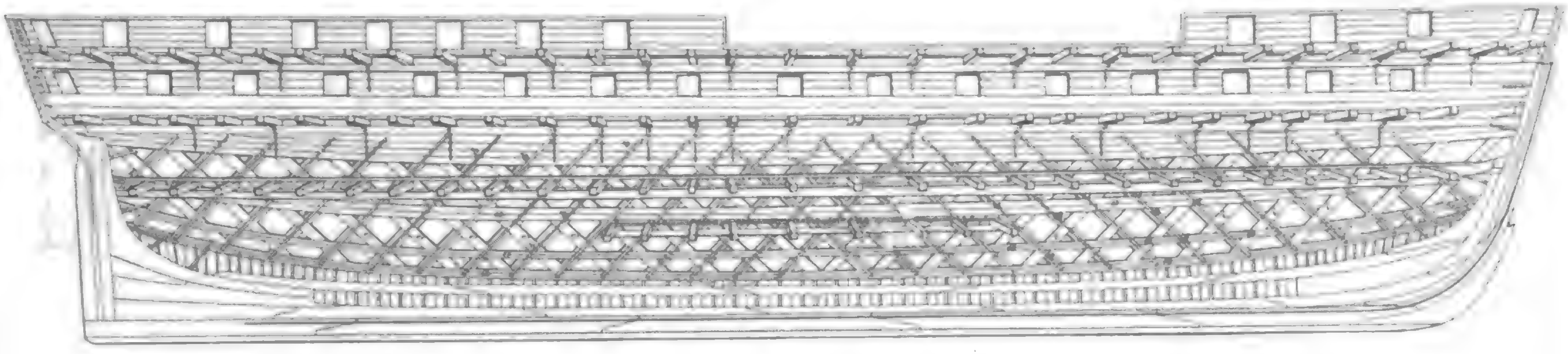
Frigate



LONGITUDINAL BINDERS & IRON RIDERS.

Plate 7



be preferable to the trussed frame; it would be also less expensive, and take up less room in the hold, whilst the connections would be more uniformly maintained, and the support it would yield would be more regularly distributed over the whole body; for when any pressure is brought upon this system of thick strakes and plates, the longitudinal binders are prevented, by the trusses (*c*, *Plate* 28) between them, from approaching each other, and the trusses are subject to a compression; whilst the iron riders (*b*) hold the whole in a mass and prevent a separation from taking place, as they are acted on in such a way that they will resist extension. The bolts which secure these riders always pass through the iron riders, besides the frame of the ship and the outside planking, so that the whole is constituted one uniform mass.*

There appears to be two points of objection to sir Robert Seppings's mode of applying the iron riders to frigates (*Plate* 27): the first is, their being inclined towards the extremities; for, with this inclination, the iron resists only edgewise any alteration in the form of the ship; consequently the whole strain is brought transversely on the fastenings, and can act only partially upon the bolts; but if they were inclined *from* the extremities, the iron riders would resist, by extension, in the direction lengthwise, any alteration in the form of the ship,—and all the fastenings would resist together. The other objection is that of bringing the lower length of the rider on the frame, instead of bringing the whole over the planking: this mode of applying it prevents the whole of the planking from acting in a mass, or as one entiretrussed frame. In whatever form trusses are applied, if it is by riders constituting a frame to act in resisting the arching or bending of the ship, it must still be considered as only a modified application of the principle at first proposed by sir Robert Seppings, when he was master shipwright of Chatham dockyard.

The other parts of this system of building are, the connection of the beams with the sides of the ship, and the mode of laying the flat of the decks. Sir Robert Seppings, in common with other inventors and innovators, had to watch the working of his plans, and to determine the ultimate application or a modification of them, as facts and experience developed their suitableness or otherwise. This observation applies particularly to his plan of leaving the beams short at one end, and having wedges so as to bring the ends of the beams and the sides of the ship into contact; and that, as the side of the ship fell out, which they used to do in small degrees before this system was tried, these wedges were to be set up to answer the purpose of the iron templates, which used formerly to be driven between the beam-ends and the side, to prevent the beam and the side from working. This was soon found not to answer the purpose, as the wedges became loose, and it was difficult to set them up, and the beams were allowed to work in a greater degree than they had done before.

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* The Committee of Master Shipwrights, who sat at Woolwich on the construction of ships early in the year 1842, proposed a combination very similar to that which has been just described.

It has been observed that the trussed frame was introduced to present a resistance to any change of form in the ship, by distributing a more uniform support over the whole system; and that by taking away the footwaling or ceiling, and filling in the openings, a greater resistance to compression was provided. As a third provision to this effect, shelf-pieces (*a, fig.* 6, *Plate* 25), and thick water-ways (*b, fig.* 6) were introduced; these not only constitute a greater resistance to extension in the upper part of the body, but they form a better connection of the beam-ends to the sides, and, by being continuous in their support, give a degree of firmness which was not obtained in the old method of building;—and when a deformation then took place, and the resistance opposed by the various parts was overcome, a working was produced amongst the parts; and as the different forces continued to act, there was a continual uneasiness produced, and effects followed which were more and more disastrous to the system, at the same time that they were a source of constant annoyance to the crew by allowing the water to pass in through the seams; and every means that was used to strengthen the combinations in the old system failed of producing a permanent improvement in it, for the additional strength given by them was soon overcome, and the parts again became leaky.

The shelf-pieces and thick water-ways were used in French and other foreign vessels before sir Robert Seppings proposed the application of them to English ships, but the shelf-pieces were applied to only small vessels, and they were neither used in a systematic form nor brought to act so much in conjunction in supporting the beams, and in securing the ends of them to the sides of the ship. The French water-ways and binding-strakes (*fig.* 7, *Plate* 25) constituted an excellent combination, and acted well in preventing the separation of the beams from the side, as the fastenings were more directly in the line of the beam, and consequently they were in the line of the pull to prevent separation; and, as a plan, it was equal in merit to the thick water-ways and binding-strakes introduced by sir Robert Seppings, if, indeed, it did not excel these: and sir Robert Seppings's plan of water-ways and binding-strakes can be considered as entitled to preference only when they are in connection with diagonal decks, to which experience and observation have pointed out some objections.

In addition to what has been stated of the combination of the different timbers which were brought on the inner surface of the frame of the ship, sir Robert Seppings introduced a new mode of combining the frame-timbers themselves by having the heads and heels of these timbers square, with a circular coak in their ends instead of chocks in their heads and heels, as they had until 1818, when the new combination was ordered to be tried. This was done to diminish the number of small angular chocks, which, without contributing to strength, promoted decay, by their surfaces shrink-

DISPOSITION OF A SHIP'S FRAME,

Showing the old and present Methods of uniting the Timbers.

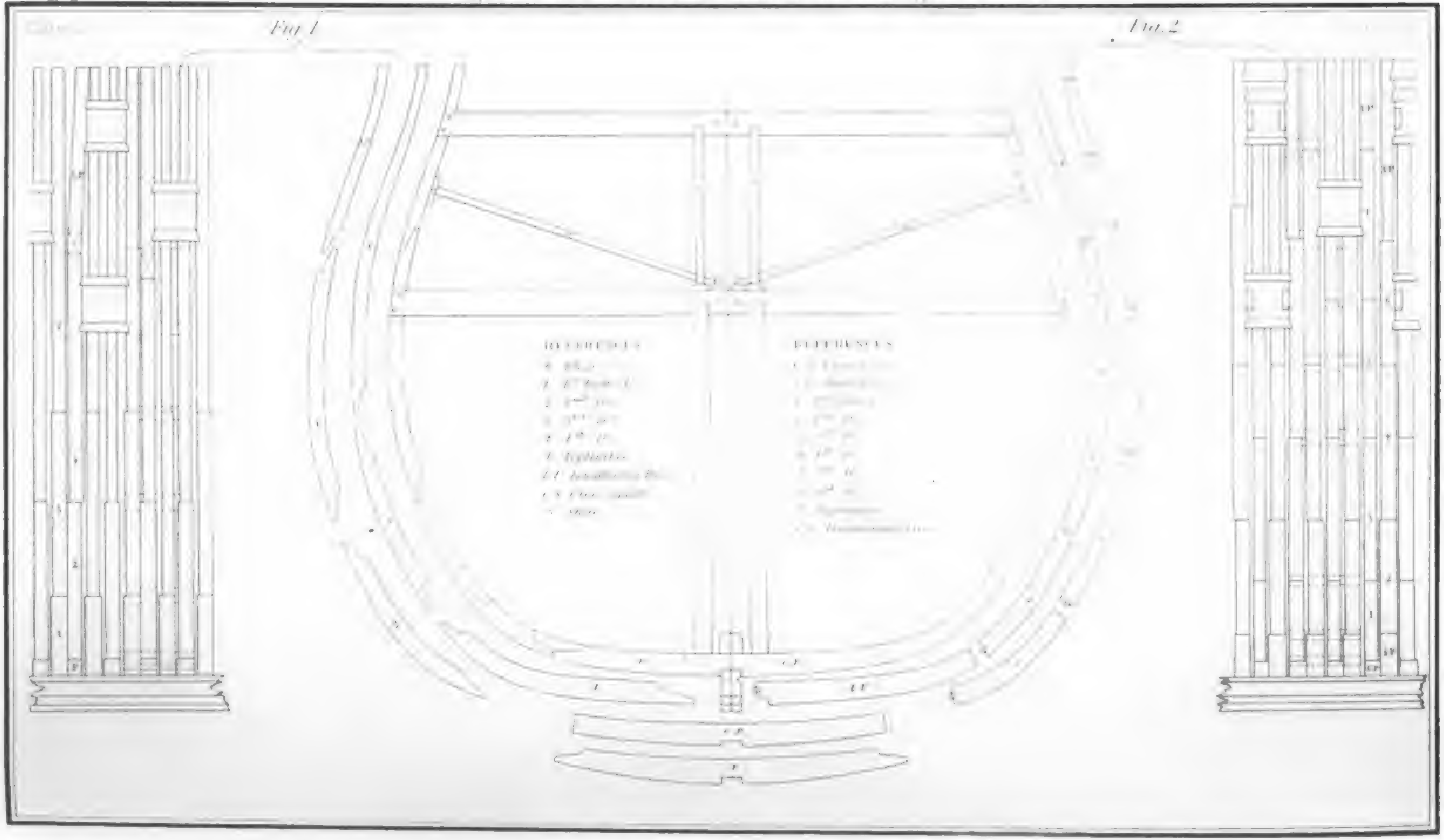


Fig 1.

Old Square Stern, as built in 1758

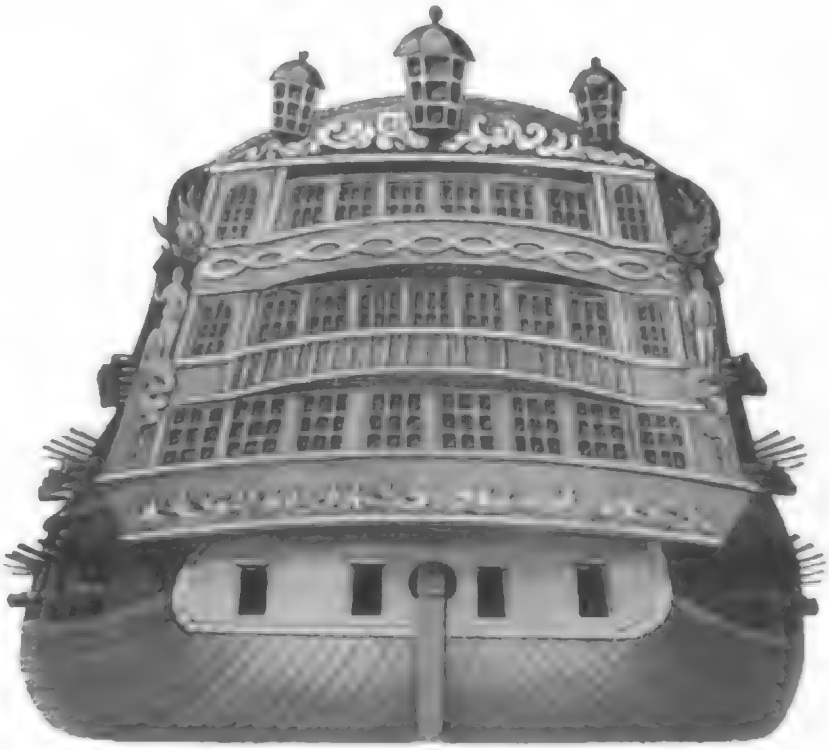
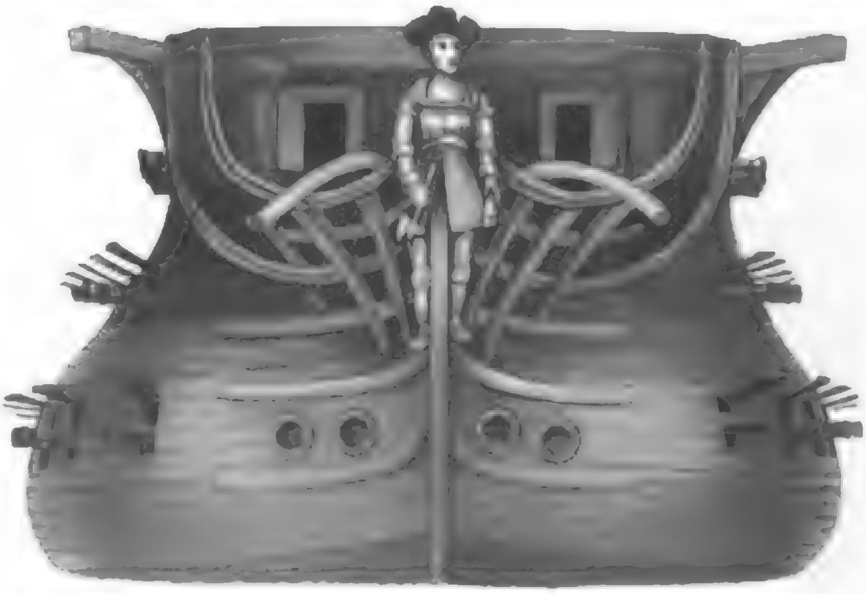
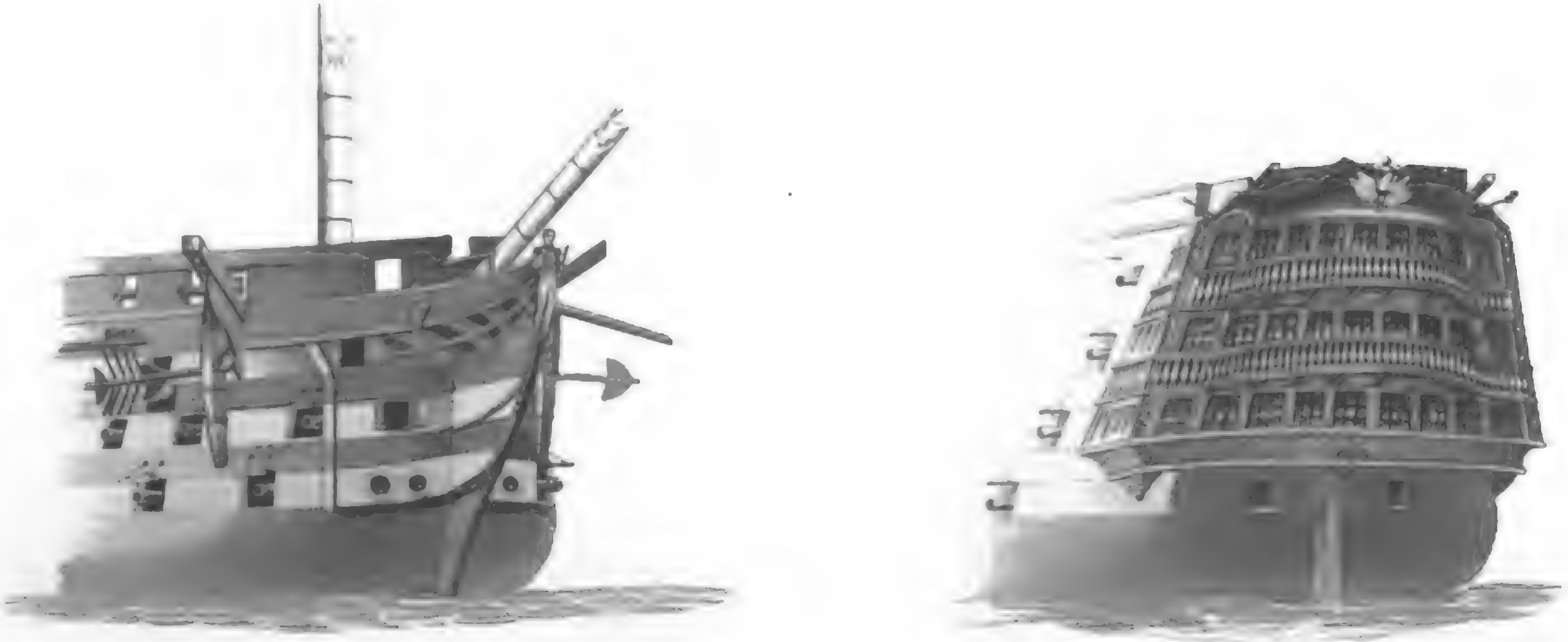


Fig. 2

Old Beak head





ROUND BOW & SQUARE STERN, AS BUILT IN 1820.

ing, and openings being formed for the accumulation of filth and the growth of fungus. The heads and heels of the timbers, as they were formerly combined with chocks, are shown in *fig.* 1, *Plate* 29, and the square heads in *fig.* 2. The use of chocks at the heads and heels of the timbers was introduced in 1714, with the view to the more advantageous conversion of timber.

That a substantial bow and stern, so constructed as to mount a good armament, at the same time that they constitute a protection to the men when they are fired into by the enemy, is a matter of great importance in naval engagements, must be obvious; but this sufficiency of armament and protection could not be had with the bows and sterns constructed after the old method. Previously to the introduction of sir Robert Seppings's alterations, the bow was straight across at the cat-head, so low as to be in a line with the upper-deck portsill, (*Plate* 30, *fig.* 2,) and was boarded across with thin boarding and stantions. But as this was not sufficient to resist even grape-shot, the crew were much exposed to the raking fire of the enemy; for it was observed in the *Victory*, after the battle of Trafalgar, that whilst in many cases the largest shot had not gone through the round and solid part of the bow, the grape-shot had passed through this bulk-head. This was not the only defect in the old form of the bow—it was deficient in strength; and although it had to resist the greatest impulses, yet it was one of the weakest parts of the ship, and was constantly subject to leaks, by which the stores in the gunner's store-room were exposed to damage; and as the leaky condition of the bow admitted the water, it diminished the durability of the ship. An alteration was then necessary for strength, for the preservation of the ship from decay, for the preservation of stores, for the comfort of the crew, and for the purpose of armament and protection.

To have the bow constructed with effective capabilities for offence and defence, is justly deemed a matter of primary importance in construction, and the alteration which was made supplied what was deficient in the several respects just mentioned. The superior manner of combining the two sides, and the more suitable disposition of the hawse-timbers, have rendered this connection as complete as that of any part of the ship—complete both as to strength and tightness; whilst the whole of the bow is equally strong to bear the percussion of shot. The carrying of the rounding of the bow completely up has also made it practicable to arm the bow, so that in some of the three-decked ships twelve guns may be fired in lines parallel to the keel, whilst some frigates may fire similarly six guns. (*Plate* 30, *fig.* 2.) The *Namur*, which was cut down in 1804, was the first ship that had the round bow left on, but it was several years afterwards that the improvement was first applied to new ships.

The other alteration affecting the armament of the ship, was that of giving a circular form to the stern. This provided for a more formidable battery, of such a form that guns might be run out so far as to diminish the danger from the explosion; and the construction was also such as to give much greater strength to the stern of the ship. The old square stern (*Plate* 31, *fig*. 1), was certainly not of a construction suited to present an efficient defence, and it was not strong; and it has been disputed whether sir Robert Seppings obtained, in his first construction of a circular stern, all the advantages that were desirable. But whatever might be the intrinsic value of the alteration which he introduced, there was this to be regarded in connection with it as unequivocal, that it led the way to improvement as to effect and appearance also, although, in the latter respect, it might fall below the requirements of taste. Still it must be confessed, that whilst so much depends upon efficient armament, it is a part of sound policy to secure this, although it may be necessary to surrender something desirable in appearance, and to incur some additional expense. There was this new advantage in circular sterns, that they could be armed in such a way as to leave no point indefensible—an advantage which, in several engagements during the last war, the ships with the old square sterns were proved not to possess. The importance of this more perfect defence might then be sufficient alone to determine a preference to the circular stern; but the greater protection which it provided for the men in time of action might be deemed as something additional to this importance, whilst the improvement as to strength still further enhanced the value of the alteration. The objection which has been sometimes made to circular sterns—that in time of war foreign ships are generally those which retreat, and that we are therefore teaching our enemies to defend themselves more effectually against us—appears to be without sufficient ground; for it is never certain that British ships will not be honourably placed in such circumstances as to be obliged to resort to the use of a retreating battery for defence; nor can the discretion of dispensing with a stern battery be fairly calculated on in general engagements. It is further important to provide against what is very likely to be the necessity of our navy in the event of a war, which might bring against us a formidable array of steam-ships, especially in the service of blockading, should that be again resorted to; as in such service the steam-vessels could, with much more dexterity, perform the part which was formerly conducted by gun-boats.

It was not long after the circular sterns had been introduced, when there appeared several competitors, either laying claim to the original design, or suggesting alterations by way of improvement on this design. (*Plate* 32, *fig*. 1.) In December 1819, Mr. Roberts proposed an elliptical stern, instead of the circular; but the originality of this form has been since claimed by Mr. Blake. That the elliptical stern (*Plate* 32, *fig*. 2) has a lighter and more elegant appearance cannot be denied; but whilst this is only a secondary object in construction, it may with propriety constitute a ground of preference, if it can be obtained without any practical disadvantage.

CIRCULAR & ELLIPTICAL STERNS.

Fig 1.

Circular Stern by Sir Robert Seppings

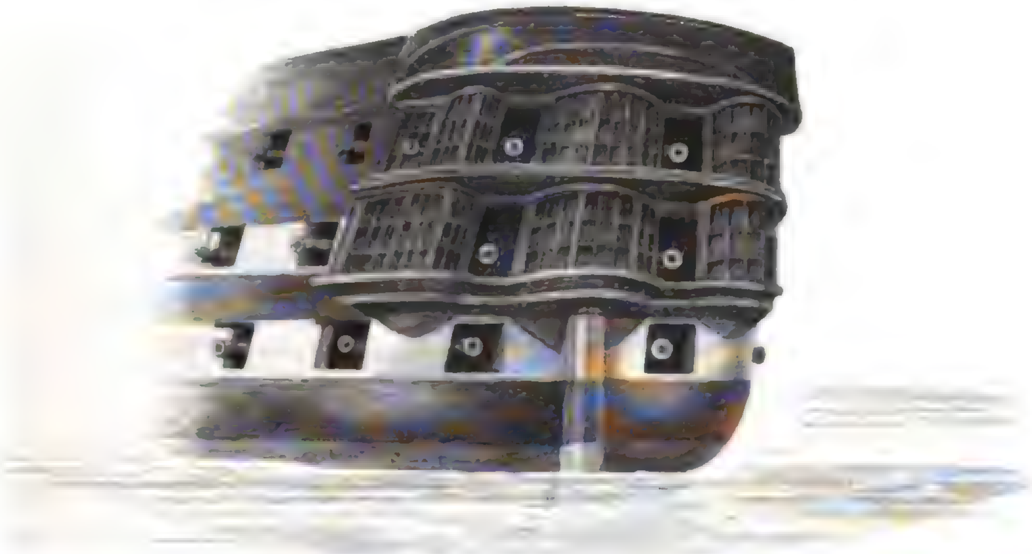


Fig 2.

Elliptical Stern

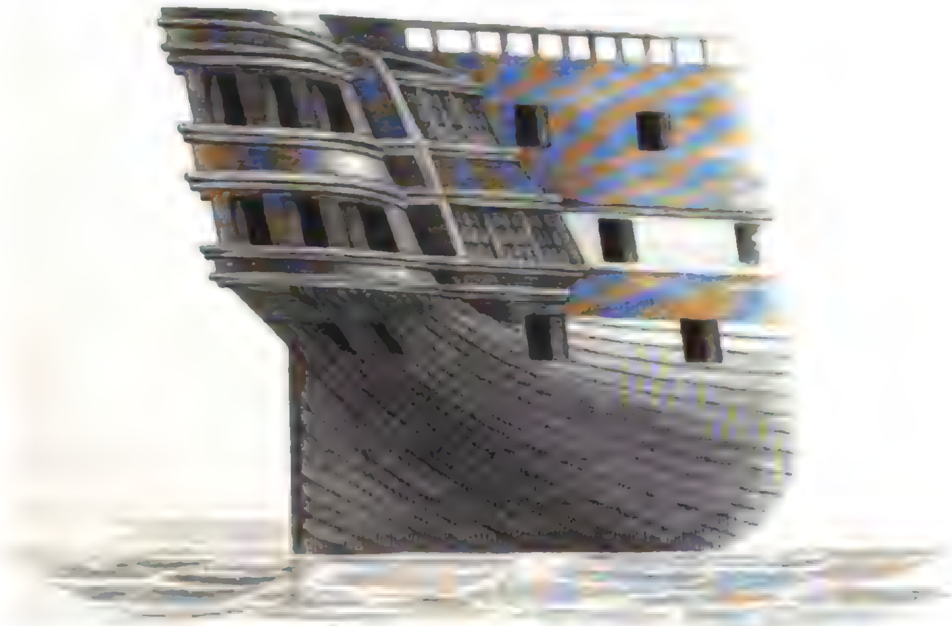
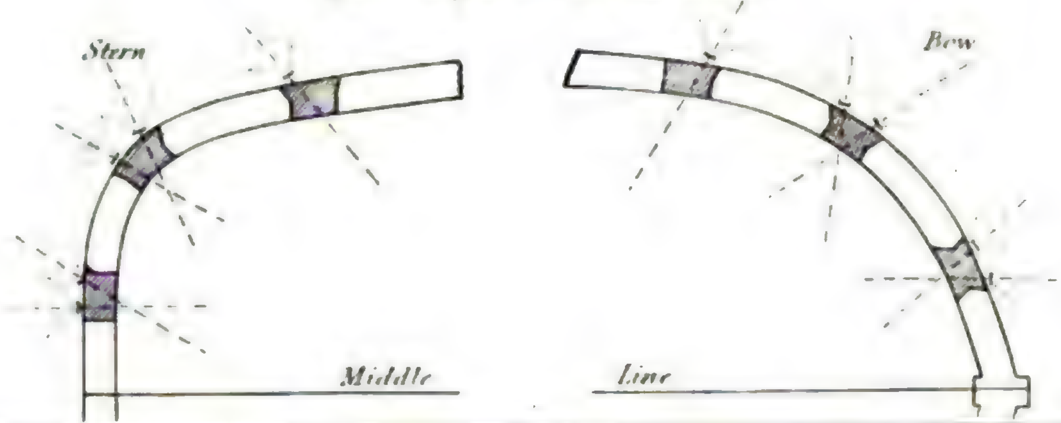


Fig. 3. Right Aft & Bow Guns.



To have effective bows and sterns is a condition which is now made imperative by the board of admiralty, a condition necessarily applicable to all classes of ships. The details of this condition should require that the right-aft and bow-guns should be fired in a line parallel to the keel without any obstruction; that the quarter-guns should train so as to cross the fire of both the broadside-gun and the right-aft guns; that the bow-guns should train to cross the fire of the gun in the next port to the bow-gun, and that this gun should cross the fire of the foremost broadside-gun; and that there should not, in any case, be an obstruction within an angle of 45° of the axis of the gun, so that the cone which is formed by the explosion may be perfectly clear of everything that would involve danger to the ship. (*Plate* 32, *fig*. 3.) Whilst these conditions are observed, the form may be varied according to the taste of the projector.

In the years 1818 and 1819 the number of seamen and marines granted for the naval service was twenty thousand. For the first of these years their maintenance was at the rate of £4 6*s*. a man per month; and for the last, it was at the rate of £4 3*s*. 6*d*. In 1818, the ordinary expenses of the navy were provided for by the sum of £2,480,680 17*s*. 3*d*., and the extraordinary expenses, by £1,787,181; and the total of the sums voted for the maintenance of the navy was £6,547,809 17*s*. 3*d*. In 1819, the sum granted for the ordinary expenses of the navy was £2,483,013 12*s*. 7*d*., and that for the extraordinary expenses was £1,631,628; and the amount of the various sums voted for that establishment was £6,527,781 12*s*. 7*d*. In the year 1820, the number of seamen and marines was increased by three thousand men, and the allowance for their maintenance was at the rate of £4 4*s*. 6*d*. a man per month. The sum granted for the ordinary expenses of the navy was £2,480,566, and that for the extraordinary expenses was £1,594,480; and the total of the various sums granted for the naval service was £6,691,345.

As peace was uninterrupted during these years, nothing of importance occurred to diversify the services of the navy, of which a moderate establishment was kept in commission, of about thirteen or fourteen sail of the line, and an average of about ninety-five sail under the line. Very few ships were launched during these years; but the removal of old and unserviceable ships from the establishment was continued, and sixteen ships of the line and ninety ships and vessels of inferior rates were sold out of the service or taken to pieces within these three years. Little diminution, however, occurred in the serviceable part of the navy. The serviceable ships in ordinary at the beginning of the years 1818, 1819, and 1820, were, of the line, eighty-seven, ninety, and ninety-one, and of the classes below the line, there were one hundred and seventy-nine, one hundred and fifty-seven, and one hundred and fifty-two; the reductions which took place were in the classes below the 24-gun frigates. In fact, the real amount of the navy had rather increased during this period: at the first of these dates, the tonnage of the serviceable part of the navy was 351,796 tons, and at the last date it was 354,992 tons,—being an increase of 3,196 tons.

From the year 1816 to 1824, nothing of a hostile character occurred to require the service of any part of the British navy. In the latter year the East India Company required some assistance from the navy, in carrying on the Burmese war; and that assistance was rendered by a squadron which co-operated vigorously with the troops employed in that service, and contributed materially to the successful result of that war.

The next naval action was that of Navarin, which was fought in October 1827. The opposite fleets were, those formed by the combined squadrons of England, France, and Russia, and those of Turkey and Egypt. The object of the combined interference of European navies which led to this event, was the repression of disorders which had arisen in the Archipelago and eastern parts of the Mediterranean sea, under the oppression to which the Greeks were subjected by their Turkish masters. In their degraded condition they carried on an extensive practice of piracy, in the objects of which there was no discrimination; and hence the Levant commerce of all countries was exposed to their depredations.

But it appeared that any temporary check which might be imposed on the practice of piracy, by sending out an armed force, would be insufficient to obtain a permanent security for commerce, unless an improvement were effected in the condition of the Greeks. The exhibition of naval power in the Levant, under vice-admiral sir Edward Codrington, in connection with the French and Russian rear-admirals, does not appear to have been designed to be employed otherwise than to restrain the Turkish fleet from carrying on the war against the Greeks, until peace could be restored by the negotiation of the mediating parties, or in the event of that negotiation proving ineffectual.

The British ships in the combined fleet were one of eighty guns, and two of seventy-four; one frigate of fifty guns, one of forty-eight, one of forty-two, and one of twenty-eight; one gun-brig of eighteen, and three of ten guns. The French had three 74-gun ships, one 60-gun ship, one 44-gun frigate, and two schooners. The Russian squadron consisted of four ships of seventy-four guns, one frigate of fifty, and three of forty-eight guns.

The combined Turkish and Egyptian fleets consisted of three ships of the line, fifteen large frigates, and eighteen corvettes, besides a large number of vessels of inferior classes, and gun-boats. The commander-in-chief of this fleet regarded with distrust the presence and interference of sir Edward Codrington. When therefore the fleet under his command was anchored in the harbour of Navarin, all the ships and vessels were arranged so that they should be able to present the best possible defence.

The combined fleet entered the harbour of Navarin, doubtless prepared for the event which it was highly probable would occur. The situation which the Turkish fleet had already assumed, indicated that a conflict was contemplated; and, as it was moored in a curve, the English and their confederates anchored to leeward, on the outside of the curve, that none of their ships might be exposed to the concentrated fire of the enemy. In a message which passed, before any hostile demonstration took place, the British admiral warned the Turkish admiral of the consequences of aggression, and informed him, that, should he fire upon the ships under his command, such firing would be resented, to the destruction of the Turkish fleet.

Some English boats, having been sent to make a communication to the commander of a Turkish vessel, were fired upon, and a lieutenant and several men were killed. The ship from which the boats had been sent, opened a fire to protect them in their return. From this commencement, the battle very soon became general. It was sustained with great energy on both sides, and lasted four hours. During this time, one ship after another, in the Turkish fleet, became destroyed or disabled. As they became disabled, they were set fire to by the Turks, and abandoned,—to the imminent danger of the combined fleet, which was to leeward; and, in the end, nearly the whole of the Turkish and Egyptian fleet was destroyed, or so disabled as to be incapable of further resistance. That part of the fleet which was *destroyed*, consisted of the following classes:—one ship of the line, three double-banked frigates, nine frigates, twenty-two corvettes, nineteen brigs, one schooner, and five fire-ships,—a number which constituted about two-thirds of the combined Turkish and Egyptian fleet, independently of the transports attending on that fleet.

The three English line-of-battle ships suffered so much in the action, that the admiral deemed it necessary to send them to England, as soon as they should have received, at Malta, the repairs which were requisite, to fit them for that voyage. And both the English and their allies sustained a considerable loss in killed and wounded.

On the Supply of Ship-building Timber.

The advantage of having a proper supply of ship-building timber, appears to have been well understood at an early period; as we find that Henry VIII., who was well acquainted with the importance of promoting the naval force of the country, and used every means towards its advancement, made laws for the planting and preservation of timber. Elizabeth also, in 1559, issued orders for preserving timber fit for ship-building.

But, it was during the seventeenth century, when the British navy was advancing rapidly in importance, and increasing very greatly the demand for oak timber, that the native resources for the supply of this article were found to be rapidly diminishing, insomuch, that, according to Evelyn, the price of oak timber had been quadrupled within a few years. And this statement is verified by a comparison of the value of timber in 1638, when Charles the First sold to sir John Wintour, the timber growing in Dean Forest, with the price of timber soon after the Restoration. In this sale of the forest timber, the king reserved for the use of the navy 15,000 tons, with a condition that any deficiency of this quantity should be supplied by the grantee, at the rate of nine shillings a ton, "or the king to take more at that rate." And in a committee of the House of Commons that sat in 1664, the value of this timber was estimated generally at 13*s*. 4*d*., and that which was fit for the navy only, at 15*s*. per ton, or about 18*s*. 9*d*. per load; being nearly double the price at which naval timber was sold in the early part of the reign of James I. The contract prices which were paid for straight and compass timber, from 1663 to 1665, varied from £2 to £2 15*s*. 6*d*.; and for knee timber the prices varied from £2 15*s*., to £3 2*s*. 6*d*. per load. And the diminution in the quantity of timber which thus advanced its price, produced some alarm as the future wants of the navy were contemplated: a few years after the Restoration, owing to the devastation made during the civil wars, and the cultivation of young timber being totally neglected at that period, the commissioners of the navy became apprehensive that there would soon be a deficiency of oak timber for the consumption of the dockyards, and represented the matter to the fellows of the Royal Society, requesting their advice. And Mr. Evelyn, one of the fellows, recommended that "an universal plantation of all sorts of trees should be encouraged, as the only way of ensuring a sufficient supply in future;" and to promote this object he published several valuable writings on forest trees, at different times, from 1664 to 1704. To a very considerable extent this advice was acted on: and he saw, within a few years, the success of the extensive and laborious inquiry which he had made, and of the advice which he gave, as the result;—for in dedicating the third edition of his work to Charles II., in 1678, he says, "I need not acquaint your majesty how many millions of timber-trees, beside infinite others, have been propagated and planted throughout your vast dominions, at the instigation and by the sole direction of this work."*

The interest excited by these writings appears to have pervaded almost every part of the kingdom, and to have continued to the end of the seventeenth century, securing a just attention to timber in the royal forests, especially in the forest of Dean, as well as promoting the cultivation of timber-trees on private estates. It appears, however, that a regard to this subject declined very materially after this period; but there was then an ample quantity of young trees advancing slowly to maturity, and no care seems to have been taken to secure a *succession* of well-grown timber. And both the commissioners of land revenue, in their eleventh report, laid before parliament in 1792, and the late viscount Melville, when first lord of the admiralty in 1810, in a letter to Mr. Percival, admit that the supplies of timber for the navy during the reign of George III., were the result of that attention to the planting of timber-trees which had been excited by the writings of Evelyn.

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* His 'Discourse on Forest Trees,' dated Sayes-court, 5th December, 1678.

In that report it is remarked that, "as it is almost universally allowed that oak trees, to grow to a size fit for the navy, require from 80 to 150 years, according to the quality of the soil, it is probable that the vast quantities of great timber consumed by our navy, during the present reign, were chiefly the produce of the plantations, made between the Restoration and the end of the last century, on private property in almost every part of England, as well as in the royal forests." And lord Melville says, "If an example be wanting of the benefits to be produced by the diffusion of a knowledge of the state of timber in the kingdom, a very strong proof is to be found in the effect which was produced by the writings of Evelyn. The vast quantities of great timber consumed by our navy during the present reign, were chiefly the produce of the plantations, made between the Restoration and the end of the seventeenth century, on private property in almost every part of England, as well as in the royal forests, particularly the forest of Dean; and which had been occasioned by the publication of the state of timber in the kingdom, and by looking the danger of a scarcity boldly in the face."

From the period of the Restoration, the price of oak timber continued to increase gradually, till about the year 1756. The contract prices at which the late navy board obtained oak timber in its rough state for the dockyards remained, then, without any increase till 1792, although the current prices had been still on the advance during those thirty-six years. The consumption of timber, too, was greatly increased during that period; and as the zeal for planting had declined from the close of the preceding century, and the royal forests had not been tended with the care that was necessary to productiveness, the quantity of timber growing throughout the country had been so much diminishing for a number of years past, as again to excite serious apprehensions with regard to the future supplies for the navy.

This was the case in the year 1771, when a committee of the House of Commons was appointed to consider how the British navy might be better supplied with timber, and to report their opinion. It appears that the evidence, which was obtained in the course of that inquiry, confirmed the apprehension of approaching scarcity which had occasioned the appointment of the committee. But as the committee moved the house to discharge that part of the order which required them to give an opinion on the subject, no means were brought before the legislature to remedy the evil,—the end of the inquiry was not arrived at,—and the means of supply were left to deteriorate, without any plan being devised to ward off the consequences of the threatened scarcity.

The sources of supply did, therefore, go on to decline during the subsequent years. In March, 1791, Mr. Nichols, purveyor of the navy for Portsmouth dockyard, addressed a letter to John, earl of Chatham, then first lord of the admiralty, pointing out generally the abuses and neglect which prevailed in the management of the New Forest, its diminished productiveness of timber suited to naval purposes, and suggesting various arrangements for increasing and improving the growth of timber trees there. The statements in that letter showed that the neglect of cultivation and protection was *general* in the forest, and that therefore, the value of the forest was constantly diminishing.* This evidence was confirmed, and, as to the diminished quantity of timber grown, it was shown to have a much wider application, when most extensive inquiries were made throughout the kingdom in the course of the same year; as the commissioners received the general information "that there had been, within memory, a great decrease of oak timber of all sizes in every part of England, but that great naval timber had decreased more than any other; and timber in hedgerows which (they said) was most valuable for naval uses, in a still greater proportion than timber growing in woods; that the stock of great timber was then so much and so generally diminished in most counties, that they would not be able to continue to furnish so large a supply as they had done of late years." And hence they conclude, "That if the prosperity of this country should continue, the consumption of oak timber for its internal purposes, and for the shipping necessary for the whole of our trade, including that of the *East India Company,* would at no very distant period, furnish an ample demand for all that could be expected to be produced on private property in this kingdom; and that such was the (then) present state of the growing timber, and the prospect of future supply, that this country would, in all probability, experience a *fatal* want of great oak timber, and become dependent on other powers for the means of supporting her navy, if care were not taken to provide a supply in future, by the improvement and better management of the royal forests, and to reduce the consumption of it by the utmost care and frugality in the expenditure."

The causes of this diminution on private estates were, to a considerable extent, such as must be expected to be permanent. The consumption of timber in the useful arts had been increasing, requiring supplies beyond the constancy of growth. The increase of population had been associated with improvements in the cultivation of the land,—a cause of the diminished supply of timber which has still gone on in this country; hedgerows had been grubbed, and the land brought more fully under tillage; and the advantages of tillage, offering more *immediate* remuneration to industry and return of capital than woodlands, it cannot be supposed, that, whilst the population continues to increase the want of those commodities which are produced by agriculture, the cultivated land on private estates will, to any extent that would affect the supplies of naval timber, be reconverted into woodland. (See pages 108 and 109.) All the information that was obtained about that time tended to strengthen the opinion, already formed, of a gradual and general diminution.*

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* The way in which the royal forests are managed is a subject highly worthy of attention at the present time.

And in connexion with the various other causes tending to produce a scarcity at that period, may be mentioned the fact of England's having lost her North American colonies, and the consequent obligation on merchants to employ British-built ships, to the exclusion of a large amount of colonial shipping which had been formerly used. It was estimated that this increase in the quantity of British shipping employed in commerce, required annually an additional consumption of 25,500 loads of timber.

The East India Company, too, had increased very largely the amount of their shipping. From the time when queen Elizabeth, in the forty-third year of her reign, granted them a charter, they went on increasing the quantity of their shipping till 1772, when it amounted to 61,000 tons. The British legislature then prohibited them to build any more ships until their amount of tonnage should be reduced to 45,000 tons. Their ships were reduced to this quantity about 1776, when building was again proceeded with; and in 1792 the company's ships amounted to 79,913 tons. In 1811 their English-built ships amounted to about 110,000 tons,—an increase provided for by the average annual addition of about 1770 tons of shipping; besides any increase made by the building of ships at Bombay.

But, above all, the navy itself had lately risen to an unprecedented magnitude. The progressive increase by which it had reached its present state had, in fact, been almost continuous from the time when it became a national establishment, in the reign of Henry VIII.

	Tons.
At his death it amounted to	12,455
During the reign of Edward VI., it declined to	11,065
And at the death of Queen Mary, it was only	7,110
In the reign of Elizabeth, it increased to about	17,110
But by 1618, it had diminished to	16,040

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* The value of forest land depends very much upon the facility or the difficulty with which the timber may be conveyed to the place of consumption. And in some parts of this country the great expense of land-carriage in getting the timber to market, is a discouragement to the cultivation of timber-trees; sufficient instances of this are seen in several forests, which have been much neglected, and become almost unproductive of valuable timber, in consequence of the great expense of land-carriage, in addition to other expenses, rendering the cultivation of timber-trees unprofitable. The formation of lines of railway, passing the locality of forests from which there is no conveyance by water, would greatly increase the value of this species of property; and as it would supply inducements to the cultivation of forest trees, it might be made to subserve the national advantage of obtaining a more ample produce of timber in our own country, than there has been of late years.

	Tons.
And of this, rather more than one-fourth was deemed unserviceable.	
At the beginning of the civil war, it was	22,400
And at the Restoration, it was	57,463
In the reign of Charles II., it rose to	103,558
But at the abdication, it was only	101,892
At the death of William III., it was	159,020
At the death of queen Anne, it was	167,219
At the death of George I., it was	170,862
At the death of George II., it was	321,104
In the year 1806, it was	776,057
And in 1810, the 50th year of the reign of Geo. III., it was	800,000
At the death of George IV., in 1831, it was	544,846
At the death of William IV., in 1837, it was	536,033
And in 1847	645,550

This includes the steam, as well as the sailing part of the British navy.

It was towards the close of the last century, when the naval and commercial shipping of Great Britain increased so rapidly the demand for timber suited to ship-building, that the greatest apprehensions were awakened at the obvious diminution, as it has been remarked, in the sources from which supplies of oak timber could be obtained. Having received, from all parts of England, concurrent information as to this fact, and with the view to a fair exhibition of the subject, the commissioners cited the accounts of two surveys of some of the royal forests, which were made at an interval of about 175 years. The first of these was made when James I., desirous of improving his exchequer by a sale of timber, caused the woods and forests to be surveyed, that it might be known what could be sold. The second survey was made by order of the House of Commons, in the year 1783; and the result of the returns is shown in the following table:

	1608.		1783.	
	Timber fit for the Navy.	Decayed trees.	Timber fit for the Navy.	Decayed trees.
	Loads.	Loads.	Loads.	Loads.
New Forest	115,713	118,072	33,666	1,713
Aliceholt and Woolmer	13,208	23,934	6,985	5,924
Bere Forest	4,258	8,814	161	175
Whittlewood Forest	45,568	1,472	4,820	7,200
Salcey Forest	23,902	1,673	2,497	5,653
Sherwood Forest	31,580	111,180	2,326	14,889
Totals	234,229	265,145	50,455	35,554

Hence it appears that the sound and valuable part of the timber growing in these forests, had been diminished in a greater proportion than three-fourths, in the period which elapsed between the two surveys; and, but for the interest which had, in the meantime, been excited by the writings of Evelyn, the decrease would doubtless have been still greater.

A great quantity of the largest oak timber produced in this country, was appropriated to the royal navy; and the average consumption of British and foreign oak in the naval service, in the government dock-yards and in the merchants' yards, from the year 1760 to 1788, amounted to 50,542 loads annually.

But in estimating what quantity would be sufficient for the maritime wants of the country, the vast amount annually consumed in the building and repair of commercial ships and vessels must be taken into the account. And it was estimated, from evidence obtained in the year 1791, that this consumption amounted, one year with another, to about 167,829 loads, including the East India Company's ships, and transports and other vessels employed in the service of the government. Adding to this, the average annual consumption for the navy as above stated, the total amount required annually would be about 218,371 loads. But the quantity of shipping employed in commerce continued to increase rapidly, demanding every year a greater quantity of timber. In 1801 the whole amount of British mercantile shipping was about 1,725,940 tons; and it went on increasing, so that in 1808, lord Melville stated the quantity of timber used annually for this purpose to be 349,900 loads.* This consumption then, it seems, diminished; as, in the returns made in 1811, the amount is stated to be about 258,679 loads; in the same year, the amount of British mercantile shipping was 2,163,094 tons; and by the year 1816, it had increased to 2,489,068 tons, exclusively of the ships belonging to the settlements: and the annual consumption of timber necessarily increased too. In 1846, the sailing part of the commercial shipping registered in the ports of England, Scotland, Ireland, the Channel Islands, and the Isle of Man, amounted to 3,089,429 tons; in the same year, the commercial steam-ships and vessels amounted to 131,256 tons. Estimating the average duration of sailing ships and vessels to be twenty-five years, then the quantity of timber required annually, to keep them from diminishing, and also to maintain them in good repair, would be about 197,800 loads. Likewise, the quantity of timber required to maintain the commercial steam navy at its present amount and in good repair, estimating that, on an average, the ships and vessels composing it will continue running for a period of fifteen years, will be about 14,000 loads.

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* The proportion of timber consumed, to the quantity of shipping maintained, at a more recent date than half a century ago, was considerably greater than it is now. This difference, in the royal navy, may be attributed, first and partially, to the great amount of repairs in ships of war, consequent on the frequency of sea-fights; and partially to the general want of economy that prevailed, as a system, in all the government dock-yards in the kingdom, at that period.

At the present time, the annual consumption in building, to maintain the royal navy at its present state, and to keep it in repair, cannot be estimated at less than 35,500 loads; whilst the steam navy requires an annual expenditure of about 11,300 loads of timber, for building and repairing, to prevent diminution. Hence, the total quantity of timber required annually for the purposes of the royal and commercial navies of this country, would be about 258,600 loads, without estimating anything provisionally on the highly probable contingency, of increase still going on in the means of naval war and in those of commerce. The royal navy amounts to about 532,500 tons of sailing ships and vessels, and to about 113,050 tons of steam ships and vessels; thus making a total amount of sailing vessels, of 3,621,926 tons, and of steam ships and vessels, of 244,311 tons. To keep up the commercial navy at its present amount, we have seen that 211,800 loads of timber are required annually; and to maintain the royal navy in its present state, there are required annually about 46,800 loads. In estimating these quantities, we have allowed about 1⅓ load of timber to a ton of commercial shipping, and about 1½ load to a ton of shipping in the royal navy. In addition to these, a large quantity must be allowed for repairs. As foreign timber is generally sided or squared before it is brought to England, an addition must be made of about half the quantity of timber that is imported, if we would estimate what quantity must be grown to supply the maritime wants of this country; for about one-third of the timber, in its rough state, is lost in siding and squaring it.

As the consumption of oak timber has increased, and the native growth of it has not been answerable to the demand, occasioning an apprehension that scarcity would prevail, the price has necessarily increased too. Under such fear, the price rose from £2 to £2 15*s.* 6*d.* a load, soon after the Restoration. The great consumption in the latter part of the last century, having very much diminished the resources, the supply of oak timber became very small at the beginning of the present century; and the want of it was pressingly felt in the years 1802, 1803, 1804, and 1805; and the price went on increasing, till, in 1809, it was £7 5*s.* a load. By the year 1815 it had risen still higher in price, and timber of the same metings was purchased at £7 7*s.* per load. When the demand for oak timber for the navy became less, after the war terminated, the price of it fell in some degree; in the year 1833, it was as low as £6 a load, and it continued to be supplied, with but little variation of price, till 1841; and at the present time, timber of similar metings is supplied at £6 18*s.* a load.

If there were no other evidence to be considered in this matter, that which has been now brought under notice, would be enough to support the conclusion, that the produce of our forests and of the private estates of the kingdom is not sufficient to meet the requirements of the country. Yet it may be supposed, that if all the forests were brought to the highest degree of productiveness, and that every proprietor of land paid the most rigid attention to the cultivation of timber, and secured the growth of all that his land would yield, without retrenching the advantages of tillage, or diminishingt he amount or value of pasture, such universal care might obtain a full supply for the wants of the country. But since this cannot be *constrained*, it cannot be expected; and at the present time, a proportion considerably less than one-half, perhaps not more than one-third, of the whole quantity of timber expended in ship-building is English oak; the other proportions being chiefly the produce of different quarters of the world: the northern and southern parts of the European continent, British India, Africa, the West Indies, and North and South America, contribute respectively to this supply; and the occasion for this is likely to be permanent, notwithstanding any encouragement that may be given to the cultivation of oak timber in our own country. Let us then suppose that the present supply of English oak for the purposes of ship-building is 100,000 loads annually,—for the probability is that it does not exceed this quantity; but the smallness of the quantity is the direct and inevitable consequence of the inadequacy of the growth, as, besides the preference which is commonly given to English oak, it would be a part of economy, to have a larger proportion of it than can now be obtained, for the uses of ship-building in all the royal dockyards of the country.

Oak.—Foreign oak has been used in this country for the purpose of ship-building; and as early as the year 1763, when the possession of Canada was confirmed, as a part of the British empire, oak timber began to be imported from that colony; and in 1772, the quantities of oak plank obtained from that source were very considerable; but it was found to be deficient in durability, in relation to that which was brought from Dantzic, and the use of it gradually diminished. But in the year 1804, about 2,000 loads of white oak were imported; and again, in 1807, when the decrees of Berlin and Milan prevented our obtaining further supplies from the European continent, large quantities of red and white oak were imported. The white oak was cut into plank, and used in ship-building, but in a very few years it was found to decay rapidly; in 1812, the *Devonshire* was planked with this timber, which, in 1817, was totally decayed.

Not only did the British government seek to supply the deficiencies of native oak by having recourse to the colonies; but no sooner was it found that the Canadian oak was subject to early decay, than this timber came to be imported from the Baltic; and as early as 1772 a quantity of German oak was introduced into this country. In the year 1802, further supplies were obtained from the province of Holstein, and used in the building and repair of ships. But in each case this timber also was found to be subject to early decay: the inside of the timber became rotten, leaving the outside a mere shell. Instances of this were seen in the *Blake*, of seventy-four guns, built in 1808, and in the *San Domingo*, built in 1809; neither of these ships lasted more than five years, and at the end of that period they were sold out of the service.

The foreign timber, which is found to be the best general substitute for English oak, is Italian oak. One main feature of the excellence of this timber, is its curvature; and by the large importations of it which are made from the Adriatic, a good supply of compass timber is obtained for the frames of ships. This is of great consequence, owing to the difficulty there would be in getting English oak to answer the requirements of the naval service in this respect.

Larch.—Amongst the different species of timber of which the native properties might indicate its suitableness for ship-building, is larch. It has been used for this purpose, in both the north and south of the continent of Europe; but, whatever may be its adaptation, the small quantity of it which the produce of this country yields, would prevent its being used as a substitute for oak to any important extent for the purposes of the navy. It has nevertheless been employed with success, and a quantity of larch which had grown upon the Duke of Athol's estate at Dunkeld, was first used in ship-building in England in 1809; and from this species of timber, which was felled in the years 1816 and 1817, the *Athol* was built, and launched in 1820: she has been a durable ship, and by means of several large repairs, she has been kept in the service till the present time. About the year 1820, a quantity of larch thick-stuff, of a fine texture, the growth of the Tyrol and Carniolā, in Germany, was imported; and great quantities of this species of timber were obtained from Poland about the year 1838; and Italian larch, of very fine growth and texture, was used in ship-building in 1842. The Polish larch was inferior in growth as well as in quality to the Italian larch, which was supplied to the dockyards two years afterwards; the compass of this was very excellent for frame-timbers, and also for beams and plank. This timber contained a large quantity of resin of a reddish colour, as described and commended by Pliny.

Fir.—The want of oak timber, nearly a century ago, led to the use of fir as its substitute: five 28-gun frigates were built of this timber in the year 1757. There was, however, a strong aversion to the sole use of this timber in the building of ships, although the average duration of these frigates was about nine years. And the use of this timber in building entirely, appears to have been suspended for a considerable time; at length, six frigates were built of fir in 1796; these contained a portion of elm, the deadwood, floors, &c., being of this timber, which decayed rapidly. In the years 1804 and 1805, six more frigates were built of fir that had been imported from the Baltic; and the average duration of those ships was about eight years.

Pitch pine, grown in North and South Carolina and in Georgia, was largely imported in the early part of the present century, and used in the building and repair of ships; and in 1813 and 1814 this timber was used in building seven frigates, the average duration of which was six years and a half. But the selection of this timber requires to be made with considerable care, with respect to the state of its resin. Red pine and yellow pine were also extensively used in building and repairing ships; and during the years 1814 and 1815, eighteen frigates were built of this timber; fifteen of them were built of the red, and three of the white pine. The average length of service, which those built of red pine were capable of performing, was three years and a half; while those built of the white pine lasted only three years:—hence these species of pine were seen to be decidedly inferior to pitch pine, for the purpose of ship-building.

Cape Timber.—Timber has been obtained from the Cape of Good Hope also: in the years 1811 and 1812, the forests near Plettenberg bay were surveyed by Mr. Jones, a shipwright officer of Portsmouth dockyard, who selected and sent to England several specimens of wood; but, of these, the stink-wood was the only timber that became used to any extent in ship-building.* Seven specimens of timber were sent from Sierra Leone; three of which have been used in ship-building,—two, the linshinginara, and the conta and koa, on a limited scale,—and one, the turtoise, commonly called the African oak or teak, very extensively. And, from about the year 1815 to the present time, this timber has been used as a valuable substitute for English oak, in the beams, planking, and other principal timbers of ships; but it requires to be used with great care; for, wherever the range of fibre is crossed, and the heart of the timber comes to the surface and is covered over, it very soon decays. Its most useful application in ship-building is for beams. Moulmein teak has also been used in the dockyards of this country within the last three years; and it has been found very useful for beams and planking: it is likely to be brought into extensive use, being very suitable to these purposes; but its use has been too limited, in time, to show its relative durability.

Mahogany.—There has likewise of late been a large importation of mahogany from Honduras, a species of timber that has been very usefully converted into beam-pieces, water-ways, shelf-pieces, and planking: but this timber requires care in the selection; as some of it is of an open and soft texture, and is not durable.

There have been also, of late, importations of Spanish mahogany from Cuba. The growth and texture of this wood are such, that it is likely to be very useful in ship-building, particularly for thick-stuff and beams. This island also produces several other sorts of valuable wood: especially the cedar, and sabico or sabicu, of which large quantities have been obtained.

It is undoubtedly important to the naval power of England to encourage the growth of timber, especially oak, upon her own soil; yet, as the produce of this country is not enough to meet the wants of the royal navy and those of the mercantile shipping, it has become equally important to encourage the importation of timber from different countries, in order that extensive experience may be gained by ship-builders, and that they may be thereby enabled to make the best selections, so that, in a time of war, the most suitable timber may be obtained; and that, at places from which it may be the most easily brought. A judicious selection of timber is of the highest importance to the royal navy, not only because the great expenditure of it makes one of the largest items in the expenses of the navy, but also, because the durability of ships depends much upon the same thing; and further, the greatest amount of saving may be effected by economizing its use. (See the Author's "Outline of Ship-building," article "Timber.")

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* See Knowles on the Dry Rot.

On Experimental Sailing.

The history of naval architecture in England has shown so much a want of union between theory and practice; and until a very recent date, there was so prevailing an indifference to the application of scientific principles, that the chief dependence for improvement has been on experience. At the same time, the course of experience has not been marked with sufficient care to supply information by which improvement might be pursued with certainty. Till very lately, we do not find that anything more than the most general efforts and observations were made, to obtain even satisfactory inferences of superiority, even in similar ships. And all the experiments that have been made, lead us to conclude, that merely comparison of ships as they were, was the object contemplated, rather than subsequent *improvement* as the end of experiment. For, when one ship has been shown to be superior to others *generally*, the bare fact of superiority has usually been enough to indicate the propriety of taking her as a model for other ships. A few instances of deviation may be found, in which a little greater length or breadth is given to a ship built after the form and general dimensions of a ship whose qualities had been approved, and also of building on the reduced lines of an excellent ship.

The custom of building ships of certain dimensions, which had been *officially established*, was undoubtedly a check to enterprise; and it is interesting to observe its practical effect on ship-builders, whose opinions of construction were formed in accordance with what they practised. Perhaps there have been few occasions more fully illustrating this fact, than that which occurred immediately before the middle of the last century. At that time it was deemed necessary to revise the establishment of 1719, from which it had become the usage of making so many deviations, as to cause great inconvenience in fitting out ships. The several master-shipwrights were therefore directed to propose dimensions for a ship of each class; but we find that their proposed dimensions varied but little from those established in 1719; and in some cases, the previous dimensions were returned without alteration. Whilst naval architects themselves did not show much inclination to advance, there remained little to urge on improvement, which did not arise from some comparison of English and foreign ships. And this cause led but very gradually to beneficial results. In all these efforts, we remark that the aim was to realize qualities which had already been exhibited, although it might be subject to some change in the dimensions. Now, this is what was generally the usage in the British navy, until about half a century ago. There were, however, original designs; but their dimensions and tonnage were generally but little dissimilar from those of other ships; perhaps the restriction with respect to tonnage, that was always imposed on constructors, was the chief cause that their designs presented such moderate features of originality, or that they indicated so little desire to break through established forms.

In 1801, the *Plantagenet* was built by Sir William Rule, having improvement in view as its object. Her principal dimensions were 181 feet in length, on the gun-deck, 47 feet in breadth, and 19 feet 11 inches depth in the hold; her tonnage was 1777. She was defective in having too little displacement, and in some other respects. Sir Henry Peake built the *Pigmy* and *Pioneer* cutters, in 1810, by way of experiment. Their principal dimensions were 82 feet 10 inches long, 23 feet broad, 10 feet 1 inch deep in hold, and tonnage 197. The length of these vessels was too great for the cutter-rig; and after having been altered to schooners, they answered better, but were never excellent vessels. In these trials there was a want of systematic arrangement in the elements of construction, as well as of a proper register of the results of the experiments. From these we could, therefore, expect but little or no improvement.

Experimental sailing in the British navy is a very modern thing, if we include under that term, only those trials of ships which have been fitted out, and have had their powers of sailing and evolution tried in a course of competition, purposely to deduce, from the qualities they exhibited, some certain means of making better ships. Generally, those contests for superiority in sailing were nothing better than sailing matches; for when the ships had exhibited their best performances, inquiry was arrested, when it was found that the ship was either good or bad; so that the reason of excellence or inferiority remained, in general, unaccounted for.

Captain Hayes, of the royal navy, obtained the privilege of a direct trial of experimental sailing, having constructed the *Arrow*, cutter. In this performance, he deemed that he had developed a valuable principle, as her qualities were the subject of a highly favourable report, after she had been tried at sea with the *Basilisk*, a cutter, after the lines of a revenue cruiser, improved by sir Robert Seppings, of similar dimensions. Captain Hayes's principle was presumed to be applicable, and the lords of the Admiralty allowed him to give it a further trial, in the construction of the *Champion*, an 18-gun corvette. The object was to ascertain the relative merits of the systems of construction pursued by sir Robert Seppings, the surveyor of the navy, and by the School of Naval Architecture, in connection with that of captain Hayes. Sir Robert Seppings, therefore, constructed the *Pylades*, and the School of Naval Architecture, under the direction of professor Inman, constructed the *Orestes*, both corvettes of the same rate. The *Orestes* was intended to be an improvement on the *Rose*, the previous experimental ship of the same school.* But, with reference to the *Rose*, it may be fairly stated, that although she never developed any marked excellence as to sailing, yet she always worked well under sail, was a good sea boat, handy, and did her work well. Her disadvantage consisted in having too small dimensions for her force. She was tried in the Mediterranean, and her performances were the subject of so favourable a report from captain Clowes, that an order, dated 22nd May, 1821, was given to build on her lines. This order was not, however, carried into effect; and when the *Orestes* was constructed, her plan was deemed the better one. In consequence of this improvement, the two sloops, *Lightning* and *Comet*, were built after the design of the *Orestes*, in pursuance of an order, dated the 30th January, 1822; and afterwards, in consequence of captain Jones's report to vice-admiral the hon. sir Henry Blackwood, bart., G.C.B., dated the 5th of February, 1828, the lord high Admiral ordered the *Electra* to be built, a *fac simile* of the *Orestes*. Captain Hayes adopted the principal dimensions of the *Orestes*, with very little variation, for the *Champion*, which he was to construct. The restriction to a certain amount of tonnage was still in force. The problem was, therefore, to determine the best form and proportions within the prescribed limits. The solution of such a problem would have been exceedingly interesting and important, as it would have marked a certain progress in the development of truth, which had never been made before.

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* The Admiralty ordered the School of Naval Architecture, in 1821, to construct the *Rose*, at the same time that sir Robert Seppings was ordered to construct the *Martin*, both 18-gun sloops. The object of building these two sloops, was to ascertain whose system of construction could produce the better vessel. The School of Naval Architecture presented a vigorous remonstrance to the Admiralty, against placing so heavy an armament in a vessel of so small dimensions. It was then referred to the School to say what dimensions would be suited to that force; and also what armament was suited to the proposed dimensions of the *Rose*, Notwithstanding this remonstrance and subsequent inquiry, the *Rose* was ordered to be built of the small dimensions, and to carry the heavy armament. Her principal dimensions were as follows:—

	Feet.	Ins.
Length on the gun-deck	104	2½
Length of keel for tonnage	85	10
Extreme breadth	29	6
Depth in hold	13	4
Burthen in tons	397	

Armament: sixteen 32-pounder carronades; two 6-pounder guns.

Now there is no doubt that each of these corvettes was a good sailer; for the several trial cruises developed a superior power of speed, varying with changes which were made in the stowage, draught of water, trim, quantity of sail, and the position of its centre of effort. The *Orestes* and *Pylades* underwent alterations after the first cruise, which improved their weatherly qualities;—the *Pylades* had an additional depth of keel, of one foot, and had the position of her masts altered: the improvement was made in the *Orestes* by changing the position of her masts, and increasing the quantity of her sail. The two vessels, which had exhibited weatherly qualities inferior to those of the *Champion*, then obtained a decided superiority in this respect, as well as in speed. Further alterations were made; and in the subsequent cruise, the *Orestes* failed of maintaining her superiority close-hauled, and was beaten by the *Pylades*, but was still superior to the *Champion*. She continued, however, to be the fastest sailer off the wind, whilst the *Pylades* and *Champion* were equal. The result of the three experimental cruises places the *Orestes* first, the *Pylades* second, and the *Champion* third.

But nothing was accomplished by these trials towards supplying data for the naval constructor; for all the improvements, both in the sailing qualities of the ships, and in their motions in a sea, which were made after the first trial, were the effects of alterations quite irrespective of the form. The experiments showed what might be gained in the performances of a vessel, by correcting her trim, and by changing the position of the centre of effort of the sails: but beyond that, the facts of the experiments do not seem to lead us. These experimental cruises were begun in October, 1824, and ended in April, 1825. (See table of Elements.)

A further course of experiments was made in 1827. In this competition the *Columbine*, 18-gun corvette, constructed by commander Symonds, was introduced, to try her qualities with the *Sapphire*, 28-gun ship, constructed by the School of Naval Architecture, the *Tyne* and the *Challenger* of the same class, the former by sir Robert Seppings, and the latter by captain Hayes; also the following 18-gun corvettes,—the *Wolf* by captain Hayes, and the *Acorn* and *Satellite* by sir Robert Seppings.

In the first experimental cruise of this squadron, the results varied with the state of the weather; the *Columbine* and *Challenger* exhibiting decided superiority in a moderate wind; whilst the variations in the performances of the *Sapphire*, *Satellite*, *Wolf*, and *Acorn*, made it impossible to determine which of them was the best. Under a strong wind, the *Sapphire* sailed the best, on all points; whilst the *Tyne* was inferior to the rest: and the differences in the performances of the other ships, failed of establishing any feature of excellence.

Two other cruises of the squadron were performed during the summer; the ships having, previously to the former of these, undergone such alterations as the respective projectors of them considered would improve their qualities. The *Columbine* retained her superiority in moderate weather, having been improved by the alteration; the *Tyne* was likewise improved; but the performances of the *Sapphire* were not satisfactory, as to the changes she had undergone.

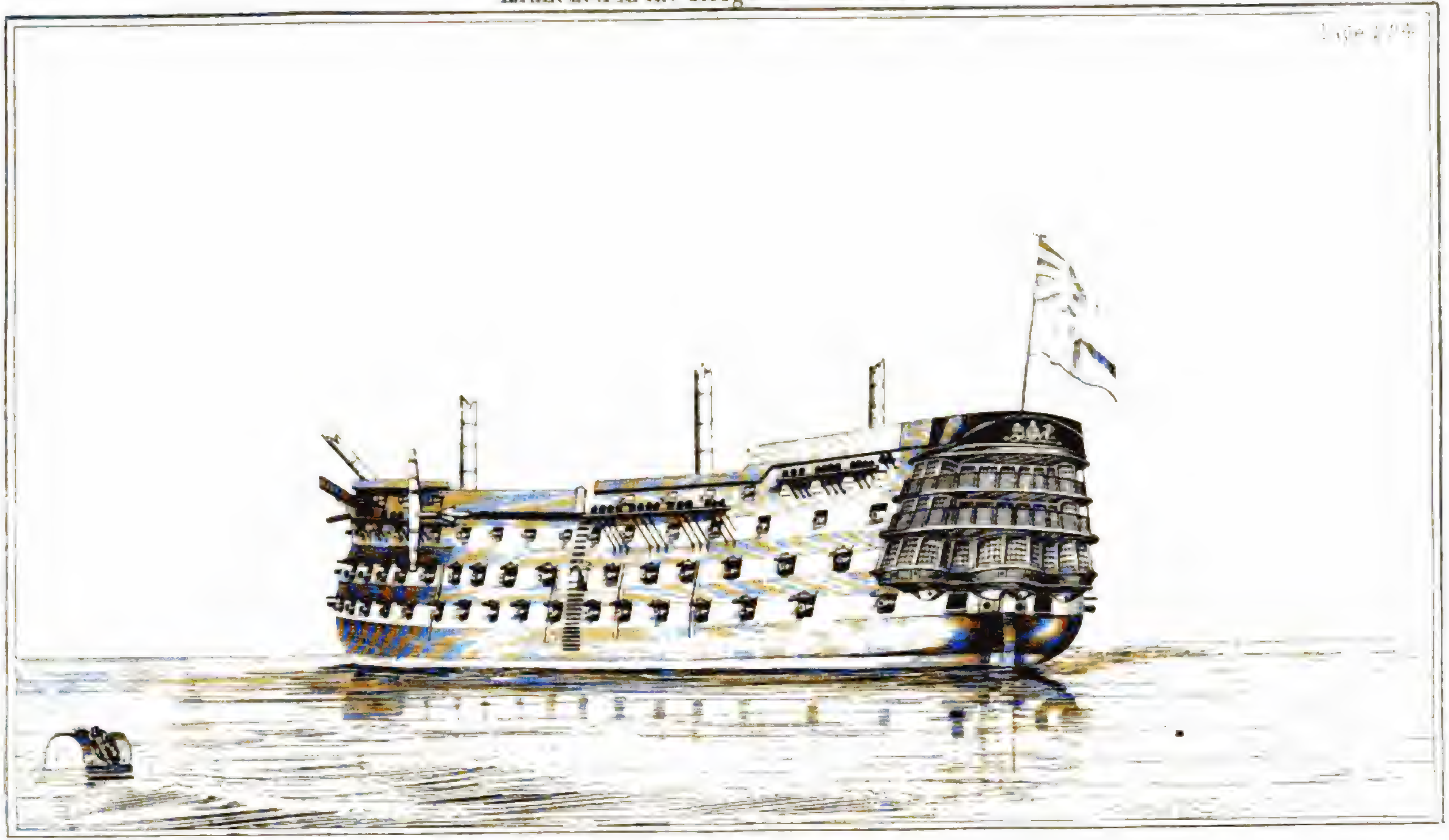
In the third series of experiments the ships were deeply laden, having taken on board six months' provisions and stores. The *Columbine* was still superior in moderate weather; but in heavy weather she failed. The *Satellite* and *Acorn* differed from her but little, in their general performances. The three 28-gun ships, *Tyne*, *Sapphire*, and *Challenger*, afterwards tried their rate of sailing together, three times; when their sailing qualities appeared to be about equal.

Not a single fact was established by these trials, conducive to improvement in naval architecture. With forms and dimensions precisely the same, as in the *Satellite* and *Acorn*, different results were obtained; and with forms and dimensions materially different, the results were not such as to establish any principle of superiority. (See tables of Elements of Construction.)

If it be asked why the question of *form* remained in the same state of uncertainty after these experiments, that it had been in before, it may be replied, that the experiments were not conducted in a way that could possibly decide it. Instead of previously concerting a well defined plan, for making observations, not only on the *sailing qualities* of the several ships, but also on all that denoted any thing of *character*, from which useful inferences could be drawn, and in respect of which each ship might be compared with other ships,—the experiments appear to have been carried out more in a spirit of rivalry than with a view to the development of truths affecting the progress of science. Even the position of the sails, and all that depends on the adjustment of the forces, appear to have been but very imperfectly investigated; and, hence, it is not known how great effects might have been obtained by a perfect arrangement of the masts, sails, and stowage. But, nothing remains to show that it was even contemplated to make observations suited to determine what effects certainly resulted from any form, by which one ship was distinguished from another.

The vessels constructed by captain Symonds, continued to gain for him enough patronage to secure his progress. He was allowed to construct the *Vernon*, free from the prescribed limit of tonnage. And, even whilst she was upon the stocks, she was considered to be the subject of such excellent qualities, that it was deemed captain Symonds had already given enough proof of his skill in naval architecture, to be entitled to the highest post and responsibility in that profession. His appointment to the surveyorship of the navy, in 1832, was associated with the entire removal of restriction as to the amount of tonnage in ships of the navy. He, therefore, had liberty for the exercise of judgment and talent in designing ships, which had not been granted to the commissioners or surveyors of the navy before; so that, he *might* at once build ships on the best conditions of

THE WATERLOO, OF 120 GUNS,
Launched in the Reign of William IV.



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excellence, that both science and practice had yet indicated. The most valuable experience in our navy had gone to show, that more discretionary power, in this regard, should be given to constructors; because, the highest developments of professional skill had not been able to reach, in practice, the excellence in construction, which was conceived to be attainable on fair conditions.

The freedom from conditions in determining the dimensions of ships, was taken ample advantage of by sir William Symonds, who, having a great principle to bring out in practice, applied it with a decision which has, in a short time, altered the general character of no inconsiderable part of our navy. Respect is generally felt for men who show themselves capable of making grand deviations from common usage, in matters of great ultimate consequence. And, sir W. Symonds has certainly the merit of having boldly taken the lead in a path which, if future constructors intend to carry on improvements in our ships, they may pursue with the highest advantage. With the liberty thus accorded, and with example in the advance, a degree of patience, equal to the processes of induction, may ensure to ships the most general combination of excellent qualities, together with an improved velocity and greater stability,—characteristics of those constructed by sir W. Symonds.

When, therefore, a new style of ship-building prevailed in our navy, the experimental sailing which took place, had immediate reference to the qualities of ships of the new construction. And many returns and reports of the sailing qualities of ships, were made between the years 1832 and 1844; the ordinary feature of which was, a statement of the excellent performances of the ships built on this new plan of construction. In these returns, superiority of sailing is generally accorded to that class of ships; and, when we understand that they were called for most especially in those cases in which it might be expected they would bear that character, we are not surprised at their common similarity. But, if we hold firmly to the letter of truth, we must suppose that there could not be in the navy, at the same time, as many *best* ships as almost the entire number that were built on the plan of great breadth of beam, and diminution in breadth immediately below the water-line.

Admit, however, that some of these ships possess the qualities from which fast sailing and other superior performances result, and there still remains a radical defect, for which no qualities they can exhibit will compensate. For, whilst fast sailing and easy evolution bear their high value in every ship in the navy, capabilities of going into action with advantage, are of paramount value in the duties of naval warfare. Neither the height at which a ship will carry her lee ports under a press of sail, nor her easy motion in rolling, will compensate for excess in the quickness or extent of that motion. Because it is necessary, in reducing her sail for action, to subject her to the influence of the waves, and to leave her, without the power of sail, to balance the hull against their effects. There is, therefore, no compensation provided to ships built on principles of which one of the necessary consequences is quickness and excess in rolling, —leaving the use of the guns subject to great uncertainty. The superiority of one ship to another in cruising, must be allowed to possess *only* its intrinsic importance in estimating her worth; for, it is by a ship's fitness for the practical duties of active war, that she answers the object of an integral part of a navy—national protection.

It is not necessary to refer to many of these ships, which have been the subjects of highly flattering eulogiums:—The *Pantaloon* is reported to have sailed, close-hauled, with smooth water, nine knots four fathoms an hour; and, before the wind, in moderate weather, with all sail set, twelve knots;—and to have been beaten only by the *Vernon* and *Snake*. The *Pandora* is recorded to have sailed, under whole or single reefed topsails and top-gallant-sails, close-hauled, with smooth water, ten knots an hour; and in scudding, in moderate weather, with all sail set, twelve knots: and to have beaten all the vessels with which she had been tried. The *Pique* is reported to have sailed, close-hauled, with smooth water, under whole or single reefed topsails and top-gallant-sails, nine knots an hour;—and, in common with the other vessels named, to possess other superior qualities.

The trial sailing which took place between the *Castor* (constructed by sir Robert Seppings), the *Pique*, and the *Ringdove* (constructed by sir William Symonds), in March 1835, under the command of lord John Hay, fully proved the superiority of the *Castor*, although the trim of the *Pique* was altered to secure some advantage,—by means quite inadmissible, had the trial of sailing been to come up with an enemy in war. The *Ringdove* was generally inferior to the *Pique*.*

The inferiority of the *Pique* in relation to the *Inconstant* (constructed by captain Hayes), was shown in the trials of sailing, under the command of rear-admiral sir Charles Paget, in October 1836, when the sailing qualities of the *Pique* were tried with the *Bellerophon*, *Vanguard*, *Pembroke*, *Inconstant*, and *Pantaloon*. Although there was not *much* difference in the rates of sailing of the *Pique* and *Inconstant*, yet superiority was almost always indicated of the latter. The performances of the *Pantaloon* were generally inferior to those of the *Pique*. The *Vanguard* exhibited superior power of sailing in these trials, and was generally before the *Pique*.†

In the year 1835, the *Barham*, *Vernon*, and *Revenge* were tried together in the Mediterranean; and, in a series of experiments, the *Barham* established a claim to superiority over the *Vernon*, in point of sailing, without any characteristic of relative excellence having been strikingly exhibited in contrast by either of the two ships, although the *Vernon* was highly spoken of on account of her great stability,—the *want*, rather than the *excess* of that property, having been generally the more observable. The *Barham* had been described as "remarkably stiff;" but the *Vernon* inclined less than she, under canvas. In some points of evolution, each of the two ships had a partial advantage; there was but little difference in their wearing and staying generally; yet, whilst the *Vernon* was said to "stay very well in smooth water," her staying was said to be "uncertain against a head-sea:" her pitching is stated to have been "very deep, and more so than any ship-of-war we have ever sailed in; and, when pressed with sail, in a heavy sea, so much so, as to endanger the bowsprit and masts."*

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* See Parliamentary Paper, No. 105 (A), Sess. 1839, pages 143, 145.

† See Parliamentary Paper, No. 105 (B), Sess. 1839.

Notwithstanding the very careful manner in which the performances of the rival ships, *Barham* and *Vernon*, were noted by Mr. Bellamy, the master of the *Revenge*, the detail of the experiments does not supply sufficient data to be used with advantage in future constructions.†

In July and August, 1836, the sailing qualities of the *Bellerophon*, *Vanguard*, *Cornwallis*, *Pembroke*, and *Minden*, were tried in competition, under the command of rear-admiral sir Charles Paget. In the three days' trial, the *Vanguard* showed a superiority, in sailing, over the *Bellerophon*. Scarcely a material difference of sailing power was seen in the *Bellerophon* and *Pembroke*; whilst, both the *Cornwallis* and the *Minden* showed an inferiority to the others.

In April and May, 1837, the trial sailing between the *Pique* and *Inconstant* was repeated, under the command of captain Mends, of the *Talavera*. The results were decidedly in favour of the *Inconstant*, in running before the wind, as well as in working against it. In the course of the summer, these two frigates were tried again in the Mediterranean, with the *Castor* and *Hercules*. In these trials, the *Castor* beat the *Pique* five times out of seven: one trial was deemed unsatisfactory. The *Inconstant* was always first in those trials in which she was in company. And the Report states,—"Further trials are not necessary, to decide which is the fastest ship, as the *Inconstant* will always take the lead in any weather and under all circumstances." In characterising these three frigates, sir J. J. Gordon Bremer said, "I have no hesitation, however, in expressing my opinion that the *Inconstant* is decidedly the superior. The *Pique's* sailing evidently improved latterly; and, I learn from Captain Rous, that the fact may be accounted for, by his removal of the forecastle guns, and two bow guns, on the main-deck, as far aft as possible, and her store-rooms clear."—*Letter to the Secretary of the Admiralty, 2nd August*, 1837.‡

In February, 1838, the *Calliope*, *Vestal*, and *Electra*, tried their rates of sailing together, both in running free and close-hauled. They carried full sail and studding-sails in running, and their rate was about ten knots.

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* Report of Captain Sir G. A. Westphal and Officers.

† See Parliamentary Paper, No. 244, Sess. 1836.

‡ See Parliamentary Paper, No. 105 (B), Sess. 1839.

The *Vestal* gained on the *Calliope* about two cables' length in three hours and a half, and the *Electra* lost about half a mile. Close-hauled, they carried double-reefed topsails, courses, and fore-topmast staysails, and the rate of sailing was from 8 to 8½ knots. And in the course of nearly three hours' trial, the *Vestal* for some time fore-reached a little, but did not weather the *Calliope;* but, ultimately, captain sir Thomas Herbert says, "*Vestal* did not gain on *Calliope,* and the *Electra* dropped about one mile during the period." (Letter to Lord A. Beauclerk, 1st March, 1838.)

In 1844, a few experiments were made on the sailing qualities of the *Queen, Caledonia, St. Vincent,* and *Albion.* The two objects of attention stated in the report of rear-admiral Bowles, were the comparative rate of sailing and stability. According to this report, the *St. Vincent* showed, under all circumstances, a decided superiority in sailing. The *Albion* is also reported to have been a very fast-sailing ship; whilst the *Queen* and *Caledonia* were inferior to the others. The stability of the *Queen* and *Albion* was reported to be decidedly greater than that of the *Caledonia* and the *St. Vincent.* But the weather was very fine during the time all the trials were made, and there was, therefore, no opportunity of comparing the character of the ships under diversified circumstances.*

The sailing of the squadron of experimental brigs, *Cruizer, Daring, Espiègle, Flying Fish, Mutine, Osprey, Pantaloon,* and *Waterwitch,* about the same time, was conducted with great attention by captain Corry, the commodore, as the elaborate report, which he subsequently returned, fully shows. He directed a regular course of observations to be made and registered in every ship, in order to show the effect produced by both wind and sea. These observations related to the power and state of the wind, rate of sailing,—points near the wind,—angle of the main-yard with the keel,—angle of lee-way,—common inclination,—angle of pitching,—angle of 'scending by the stern,—time of pitching from and to a horizontal line,—time of 'scending from and to a horizontal line,—position of helm,—state of the sea,—greatest roll to windward,—and quantity of sail set. These observations were required to be made whilst the vessels were "close-hauled." Other facts were directed to be recorded in sailing with the wind on the beam or quarter, or in sailing before the wind; as, angle of the greatest lurch to leeward,—angle of the greatest lurch to windward,—time of rolling from and to the greatest lurch each way,—angle of rolling,—and time of rolling through the greatest inclination each way.

The system adopted by captain Corry had been recommended by the author in a Letter to sir James Graham, in 1832, when he was first lord of the Admiralty; and such a fund of information as might be obtained by this means, supposing the experiments to be made under circumstances which should give to each ship an opportunity of displaying her best qualities, and if the statements were made truly, would be of great advantage in naval architecture.

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* See Parliamentary Paper, No. 394 (A), Session 1845.

The following statement of the course of experiments, is an abridgement of captain Corry's report:—"A summary of the result of the trials is naturally divided into those which took place 'on' and 'off' the wind. There were in all fourteen trials, eight of which were 'on,' and six 'off' the wind. Of the eight 'on a wind,' two are excluded, in consequence of thick hazy weather at their conclusion having rendered abortive every attempt to obtain the correct distance of the different vessels. The remaining six may be thus divided: three with moderate or light breezes, and three with strong breezes, or squally weather. The other six trials, which took place 'off the wind,' are classed under the three heads, 'wind abeam,' 'abaft the beam,' and 'right aft,' two trials having taken place with the wind in each of those directions.

"In the first of the trials 'on a wind,' the *Espiègle* and *Mutine* did not take a part, being absent. In the fourth, the *Daring* did not participate; and the *Pantaloon* was not present at the seventh.

"In the first of these trials, with the water smooth and a long swell, the *Flying Fish* had the greatest advantage; the *Osprey* and *Daring*, slightly differing from each other, coming next: but in a subsequent trial, when the wind was similar, but where, instead of smooth water, there was a cross head-sea, the *Daring* was the most weatherly, the *Flying Fish* and *Espiègle* coming after her, being followed, but at some distance, by the *Mutine* and *Osprey*. The details of this trial show, that for three hours, when on the tack with a following sea, there was comparatively little difference between the *Flying Fish*, *Espiègle*, and *Daring*; but afterwards, when they were brought to bow the sea, the advantage was chiefly gained, which, in two hours, gave the *Daring* a great superiority over the other two.

"On the fourth trial the *Espiègle* beat the *Flying Fish*; but in the seventh the order was reversed, by the latter weathering the former. The *Mutine* and the *Osprey* may be considered as beaten vessels.

"Excepting in the fourth trial, the *Cruizer* was considerably beaten by all; and even in that, she had only a slight advantage over the *Osprey* and *Pantaloon*. The *Waterwitch* had an advantage over the *Pantaloon* in the only two of these trials in which they were both present. The preceding were the trials close-hauled, with light or moderate winds. In the other three, with strong breezes or squally weather, the *Daring* had a marked and decided superiority over all the squadron. In the first of these, the *Flying Fish* and *Waterwitch* were about equal, and were next to the *Daring*; in the second of them the former vessel, and in the third the latter, are also placed as second. In the second of these three trials, the *Flying Fish* beat the *Waterwitch* very considerably; but in the third trial the order was reversed, the latter beating the former equally as much as she was before beaten, which proves the *Flying Fish*, on a wind, in smooth water, to be the superior vessel of the two; but that, with a head-sea and strong wind, an equal superiority must be awarded to the *Waterwitch*. In the first of these trials the, *Mutine* came next, and in the second and third, the *Espiègle*, which vessel had, in the latter trial in particular, a very decided advantage over the *Mutine* and remainder of the squadron.

"In the two trials with the 'wind abeam,' the *Daring* was the leading vessel, the position of second having been occupied by the *Flying Fish* in the former, and *Espiègle* in the latter; the *Mutine* being fourth in the first, and third in the second.

"In one of the trials with the wind 'abaft the beam,' the *Daring* was first, and in the other the *Espiègle*. In the former, the *Espiègle* occupied the second place, and in the latter the *Mutine*; *Flying Fish* being third in both. The *Waterwitch* was last in the first of these, and the *Daring* in the second.

In the first of the trials before the wind, the *Flying Fish* was first, and in the second, the *Pantaloon*; the *Daring* being second in the one and the *Cruizer* in the other; the *Espiègle* and the *Waterwitch* occupying respectively the last place." *

If theory were sufficiently developed, ships might be launched from the slip, equipped, and sent to gain a permanent character in competition with perfect fairness. But this is not the case. Some deficiencies, on being discovered, might be easily remedied, and the performances of a ship be thereby essentially altered. On this consideration it was recommended by the author, in the second edition of his "Outline of Ship-building," in reference to the earliest experimental cruising of British squadrons, that each ship should be first tried separately, in connexion with some ship not subject to changes; and, if necessary, any alterations made in the ship under experiment, till she exhibited her highest qualifications; and then the essential qualities of the ships might be compared without much hazard of an erroneous result. But without some *series* of experiments on ships, either separately or collectively, affording to constructors an opportunity to make any improvements which experience may suggest, it cannot be known to what cause failure is to be attributed. Nor can the cause of excellence be any more certainly determined, if a ship is tried under only one condition. There are found to be such alternations of superiority and inferiority in vessels, that the causes of these results require an investigation far more rigid than could be conducted on data which experiment has yet supplied.

An illustration of the preceding remarks is supplied by the subsequent performances of the *Mutine*, the companion of the *Osprey* as "*beaten vessels*," in the experimental cruises of the brig squadron. On the first day of those trials, this vessel carried away her jib-boom; and during the course of them, the jib could never be fully set. The use of the topmast stay-sail, and of the boom main-sail, was also very imperfect during the trials. She was, therefore, obviously under a permanent disadvantage in the general competition. Further, she had been constructed more with a view to *general* usefulness, than with reference to any *particular* service or point of sailing,—determined by a conviction that the value of this class of vessels would be enhanced, by a capability of going into shallow water; and a persuasion that the advantages she might gain by a superior fitness for duties which would lie within such conditions, would overbear other advantages which might be surrendered in securing these. Whatever might be the benefit of having a small draught of water, was realised in a higher degree in the *Mutine*, than in any other of the experimental brigs. Still, the qualities which this would secure, were not to be held unimpaired, if those of another order were to be insured. It is certain that a greater hold in the water would be an advantage in some states of the sea, and on some points of sailing. In an agitated sea, a ship is tossed about little or much, greatly in relation to the hold which her body has in the water; and therefore, if her draught of water is easy, or moderately small, she is so much the more under the influence of the waves than she would be, if her draught of water were large. This influence is the most powerful when a ship is going free, or before the wind. The advantage of a relatively great draught of water is experienced also, when a ship is on a wind, or is sailing close-hauled; as the greater depth presents proportionably more lateral resistance; and by this means she is enabled to hold a better wind;—or it makes her more weatherly, in particular with a heavy head-sea. Although this may not be the *primary* cause why one ship weathers another, yet it is a very important condition of weatherly qualities, in connexion with the best position and trim of the sails. It is not clear how much of the disadvantage to which the *Mutine* was subject, was owing to her small draught of water; for in her *first* performance she gained an evident advantage over the *Espiègle* and *Cruizer*, in whose company she left Chatham. In the course of sixteen hours, the brigs tried their qualities in working to windward, in sailing with the wind abeam, and on the quarter; and the *Mutine* arrived at Spithead an hour and a-half before the *Espiègle*, and beat the *Cruizer* about twenty miles. During this trial, the vessel had the advantage of a correct stowage, a condition which was partially lost in the experimental cruising, by the weights being carried too low down. This error was corrected after that cruising terminated, and before the vessel was again sent to sea.

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* See Parliamentary Paper, No. 394 (B), Session 1845.

In the following January, the *Mutine*, *Osprey*, *Pantaloon*, and *Waterwitch*, had a further opportunity of trying their sailing qualities together, on leaving Plymouth. On the 15th of that month, these brigs got under weigh, with topsails, courses, jib, boom mainsail, and top-gallantsails, set. The *Osprey*, *Waterwitch*, and *Pantaloon*, had all reefs out; the *Mutine* had single-reefed topsails. Her captain says, in a letter dated 30th January, 1845, "Just outside the breakwater, whilst passing over the Panther shoal, *Pantaloon* crossed us to windward; but on going about to port tack, and bringing her head to the sea, she was soon left three miles directly astern."

On the 16th, they made a regular trial of their sailing qualities, from 9, A.M., till 4.30, P.M. It was a point of arrangement, that the *Mutine* should be in the rear at starting; and from this relative position she took the lead, in less than half an hour, and beat her companions by the following distances: *Osprey* 2120, *Pantaloon* 3132, and *Waterwitch* 3440 yards. The relative conditions were a little impaired, by the *Waterwitch* and *Pantaloon* pitching and rolling away their main-top-gallant-masts, in the uneasy motions caused by the heavy swell which then prevailed.*

The most important points of difference during this trial, were the easiness of the *Mutine's* motions, and the uneasiness of those of the *Pantaloon* and *Waterwitch*. This difference was more severely tried during a very heavy gale which came on the next morning, and dispersed the little squadron in the bay of Biscay. The captain of the *Mutine* stated that her easy motion was "the admiration of all on board;" "nor do I," he added, "recollect any vessel so easy under the circumstances. *Mutine* has not injured or carried away the slightest thing." † At this time her scudding qualities were tried in the course of three days' run, at a rate varying from seven to ten knots an hour: and the captain reported, that "instead of rolling the shot out of the racks, and the wind out of the sails, as when with the late experimental squadron, she rolled little,—neither deep nor quick.‡ This enables her to get away and behave well, on what was decidedly her worst point of sailing." The scudding qualities of the *Mutine* were afterwards further developed in a gale of wind, at the Cape station, when the East Indiamen were lying to in the offing, afraid to run into the bay; and the *Mutine* could find no companion to share with her the hazard of such a performance.

During the period in which this vessel was cruising on the coast of Africa, she had opportunities to try her rate of sailing with the *Cleopatra* and with the *Helena*; and of taking, together with other slavers, the *Diana*, a very fast-sailing vessel, which had previously been deemed more than a match for any of the cruisers on the station. On the 25th August, 1845, a trial with the *Cleopatra* took place, and was continued about seven hours, in a "moderate breeze, light head-swell, under all sail, rate seven to eight knots." It was then found that the "*Mutine* had gained directly to windward of the frigate nearly seven miles."

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* See Parliamentary Paper, No. 394 (V to Z), Session 1845.

† The only loss this ship sustained in the gale, was that of one of her life-buoys.

‡ From the performance of this vessel, after an alteration of stowage, may be seen the advantage of properly placing the weight, as to height. On this second trial, the weights of the *Mutine* had been carried up, and an increase had been made to the false keel, to give more depth in the water.

"The second day's trial, of the same duration, was equally decisive, *Mutine* having gained 11,290 yards directly to windward of the frigate." *

But her most important trial of sailing was with the *Helena*. The importance and the satisfaction of it arose out of the fact, that the *Helena* had gained the climax of reputation in the regard of her captain, sir Cornwallis Ricketts, and of others who were aware of her having been declared the fastest sailer, not only on the south African station, but wherever else she had been. This 16-gun brig came into company with the *Mutine* off Quillimane, on the 31st August, 1845; and on the next day, a trial of sailing close-hauled took place, under all plain sail, with a moderate breeze and a light head-swell: the rate of sailing was from seven to eight knots and a-half; and the result of it was, that in an hour and a-half the *Mutine* beat the *Helena* 1000 yards directly to windward.

On the following day, the 2nd September, a further trial was made by these two brigs. "*Helena* having bent her best suit of sails, filled her water-tanks with sea water, and made sundry arrangements, with the view to retrieve her *first* defeat, a second trial in turning to windward was signalled from *Helena*. Commenced on starboard tack at 7h. 15m. A.M., with a moderate breeze at S.W., under all plain sail, rate seven to nine knots. *Helena*, at starting, bore S.E. 916 yards from *Mutine*. This day's trial ended at 2h. 45m. P.M., wind S.S.W.; *Helena* bearing N.N.E., 4073 yards; the *Mutine* having gained at the rate of nearly half a mile per hour directly in the wind's eye, of one of the fastest sailers in her Majesty's service." †

Illustration needs not be further extended in this example, although it might be, from her recent performances in the Mediterranean; for it is plain enough that a vessel which could exhibit such decided superiority over the *Cleopatra* and the *Helena*, ought not to have been so unquestionably a "beaten vessel," in the preceding and more general competition. It is past doubt that much of the merit or demerit of the *Mutine's* performances depended on the trim of her sails, and stowage; conditions of the constructor's requirements, which were not fulfilled during the experimental cruises.

Other illustrations were supplied, in the performances of the *Flying Fish*, *Espiègle*, and *Daring*, when they were again tried, in March, 1845. The same relative merits were not exhibited by those brigs; the *Daring* failed of showing the sailing qualities which she had developed in the first series of experiments. And, the changes of superior sailing which took place in eleven trials, leave the results subject to a doubt that they proceeded from something distinct from the essential capabilities of the vessels. No inferences can, therefore, be confidently drawn from results of so dubious a character. When it is seen that, under indifferent circumstances, a vessel's performances are superior to what she could exhibit in contest; when it is obvious, from separate statements of those performances, that each officer aims to give the ship under his command a superior character, unless she is notoriously bad; when it is sometimes seen that, just in accordance with an officer's preference or dislike of his ship, she performs well or fails of doing so; and, when statements of the relative performances of different ships are wholly irreconcilable,—the naval constructor must draw his conclusions with the greatest degree of caution. And, it does not appear that experimental cruising has yet been extended enough, to supply data for improvement in construction; or, that it can yet be expected to lead to this valuable result, until observations, similar to those taken under the command of captain Corry, shall be correctly made and registered, under more general circumstances.

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* Letter from commander Crawford, R.N., 14th November, 1845.

† Ibid.

In 1845, between the 19th of July and the 2nd of December, some important trials of sailing were made, to determine the relative superiority of ships of the line. The ships brought into competition were the *Trafalgar*, *Queen*, *Albion*, *Canopus*, *Rodney*, *Vanguard*, *Superb*, and *St. Vincent*. In the first series of trials under rear-admiral Hyde Parker, the *Queen* had a marked superiority to any other ship in the squadron, in working to windward, generally taking the first place at the conclusion; whilst the *Vanguard* and the *Superb* were almost always the two leewardmost ships. The trials before the wind did not decide the superiority of any one ship to the rest. In the three trials, the *Canopus* occupied respectively the first, fourth, and fifth places; the *St. Vincent* the first, fourth, and sixth; and the *Queen* the first, and twice the third. The *Albion* was twice the second ship, and once the fifth; the *Rodney* was second, third, and fourth; and the *Trafalgar* was twice the last, and once the last but one. There were other trials which are not noticed, as the competition was not general.*

In the second series, under rear-admiral sir Samuel Pym, there were three trials on a wind, two of them being on the same day. In the forenoon, the *Albion* and *Queen*, being nearly equal, were the first and second; the *Trafalgar*, *Canopus*, *Rodney*, *Vanguard*, and *St. Vincent* followed in order: the *Superb* did not take a part in the trial. In the afternoon the *Trafalgar*, having had her hammocks removed from the nettings, and placed below, came, in this respect, into a condition of equality to the *Queen*, and was the first ship at the end of the trial, whilst the *Queen* was the fifth; the *St. Vincent* coming after her, last. The *Rodney*, *Albion*, and *Vanguard* followed the *Trafalgar*, in order. Neither the *Canopus* nor the *Superb* was in this trial. In respect of the first of these trials, captain

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* See Parliamentary Paper 163, dated 26th March, 1846.

Greatest inclination rolled or lurched to :—

St. Vincent	18°	Rodney	27°
Queen	23	Vanguard	42
Albion	45	Superb	40

For the trials of these ships in 1844, see Parl. Paper 394, dated 19th June, 1845.

W. F. Martin says, "the change of the wind from W. to W. by N. greatly favoured the *Queen* and *Albion*, as they were on the quarter.

"The result shows that the *Queen* gained 380 fathoms;[*] but it must be taken into consideration that she had her hammocks below, whilst the *Trafalgar* had hers stowed; and as the weight of our hammocks is eleven tons, and the surface they expose above the hammock netting 486 square feet, it is obvious that the ships were so differently circumstanced, that the apparent result of this trial is worthless."[†] Subject to the condition of equality, in the afternoon the *Trafalgar* beat the *Queen* 1474 fathoms, in two hours and five minutes; the two trials showed that the alternate superiority depended on something quite distinct from the form of the ships, whilst that, being the object of inquiry, remained untouched by the experiment.

A third trial, with a strong head sea, resulted in the ships' sustaining the following order: *Rodney*, *Vanguard*, *Canopus*, *Albion*, *Trafalgar*, and *Queen*: the *St. Vincent* was away. And captain Martin says "the *Trafalgar* has beaten the *Queen* on all occasions on which she has had to contend with strong breezes and a head-sea; and her weatherly qualities, as compared with those of every other ship except the *Rodney*, have been very remarkable.

"At the end of the gale of the 6th, carrying no more sail than was set on board the other ships, she had all the two-deckers, except *Rodney*, far under her lee; the *Vanguard* being fifteen miles dead to leeward."[‡] On the same day when this was written, captain sir Baldwin W. Walker, in reporting the sailing qualities of the *Queen* said, "I consider the *Queen* to be a most magnificent man-of-war, and in every respect superior to the *St. Vincent* or *Trafalgar*, or any ship I ever served in; she is fast, and had, on the whole, a decided advantage in sailing over every other ship in the squadron."[§]

In a trial of sailing on a wind, on the 7th October, a change in the state of the sea produced a corresponding change in the relative performances of some of the ships. At 10 a.m., when the trial began, there was a fresh breeze with a considerable swell, and the ships were "under treble-reefed fore and mizen-topsails, double-reefed main-topsail, courses, jib, fore-topmast staysail, main trysail, and double-reefed spanker. The top-gallant masts were on the deck." By half-past ten the wind had so far abated that all the reefs were shaken "out of the spanker and main-topsail, and second reefs of fore and mizen-topsails.

"At one, the wind had decreased considerably; the top-gallant-masts were got up, the sails set, and all the reefs shaken out of the top-sails.

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[*] In 2¾ hours.

[†] Parliamentary Paper, No. 305, Session 1846.

[‡] General observations annexed to Letter to rear-admiral sir Samuel Pym, K.C.B., 15th October, 1845.

[§] Letter to the same.

"The wind and sea gradually decreased soon after the beginning of the trial.

"It was very remarkable how much this ship (the *Trafalgar*) headed and weathered on the *Queen* and *Albion*, whilst the ships were opposed to a considerable swell, and how regularly the advantage over them decreased in the same proportion as the wind and sea fell.

"I consider this ship, at the commencement, had also the advantage over every other ship except the *Rodney*."

At 4 p.m., when the trial ended, the *Rodney* was the first ship by 1050 fathoms, and the *Canopus* next; the *Trafalgar*, *Albion*, and *Vanguard* were equal; the *Queen* lost 1000 on them, and the *St. Vincent* 4470 fathoms.

The relative performances of the *Rodney* are thus stated by her captain: "The *Rodney* had the advantage of the whole squadron on the 3rd with *Queen*, *Albion*, *Trafalgar*, and *Vanguard*, against a head-sea; the *Rodney* weathered considerably on the *Queen* and *Vanguard*, and also on the *Albion* and *Trafalgar*, but not so much. On the 6th, a gale from the N.W. came on about sunset, and, under a close-reefed main-topsail, fore-staysail, and main-trysail, the *Rodney* in twelve hours weathered 15 or 16 miles on *St. Vincent* and *Vanguard*, and considerably on all the rest of the squadron, but less than any on *Trafalgar*. On the trial of the 7th, against a head-sea, carrying from treble-reefed topsails to single-reefed, and top-gallantsails, the advantage of the *Rodney* was greater than any before, on the whole squadron.

"The *Canopus*, from her place in the line, has generally been nearest to us. I consider her, under the weather spoken of, the next ship to the *Rodney*; the *Trafalgar*, although weatherly, is not so much so as the *Rodney*, and slower. I consider the *Queen* the fastest ship, both by and off the wind, in fine weather."*

Captain Fairfax Moresby bears the same testimony to the good qualities of the *Rodney*, in relation to his ship (the *Canopus*), and the others: "In reference to the *Rodney*, she had the advantage of the *Canopus*, as of every other ship in strong breezes, against the ocean swell; the advantage of the *Rodney*, in the late cruise, being about the same as the *Canopus* had over the *Rodney* the first cruise, in running free; there was no particular trial; but, by a comparison of sail carried, the *Canopus* had some advantage over the *Rodney*, and greatly over the *Vanguard*. The *St. Vincent*, in blowing weather, or in strong breezes, showed a great leewardly propensity; the *Queen*, as compared with the last cruise, fell into a doubtful comparison with the *Rodney*, *Albion*, and *Canopus*. The *Trafalgar* maintained her extraordinary weatherly qualities, with want of speed; the *Albion*, I thought, did not do as well as the first cruise."†

Captain R. F. Rowley, of the *St. Vincent*, says, "My opinion of the

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* Letter from captain Edw. Collier to rear-admiral sir Samuel Pym, 15th Oct., 1845.

† Letter from captain Fairfax Moresby to rear-admiral sir Samuel Pym, 16th Oct., 1845.

Trafalgar is, that she is a very weatherly ship, and particularly in bad weather, but the other ships all fore-reached her. In moderate weather and smooth water, I always considered she (the *St. Vincent*) was nearly equal to the *Trafalgar*; as, what she fore-reached on that ship, made up for what the other gained by her weatherly qualities. But, with the *Queen, Albion, Rodney,* and *Canopus,* the *St. Vincent* had no chance, except in very light airs. Off the wind, in all weathers, and whether under a press of canvas or easy sail, the *St. Vincent* is decidedly a fast ship, though by no means so fast as the *Queen* or *Albion,* but quite equal to the *Rodney, Canopus,* or *Vanguard;* and, infinitely superior to the *Trafalgar*. The *Queen* always appeared to me a remarkably fine man-of-war on all points. In all moderate weathers, whether on a wind, going free, or before the wind, she has no competitor; the *Albion* being the next ship to her. The *Albion's* superiority over the other two-deck ships, and particularly the *Rodney,* ship of her class, consists chiefly in her being much stiffer under a heavy press of sail. In strong breezes, on a wind, I did not perceive much difference between them, except on one occasion, when the sea was right ahead, the *Rodney* beat the whole squadron, and appeared much easier than the *Albion*. In moderate weather and smooth water, the *Albion* is the fastest ship; and, off the wind, will always beat the *Rodney*. Before the wind, and in a heavy swell, the *Rodney* would fight her lower-deck guns better, and with more safety than the *Albion*. The *Vanguard* appeared to pitch deep and heavily during the trial, in a head sea, and also rolled deeply before the wind. I could not perceive much difference between her and the *Canopus,* on a wind; but, off the wind, the *Canopus* was certainly the fastest ship. The *Canopus* is not so weatherly as either the *Albion* or *Rodney,* but fore-reaches considerably."*

Captain N. Lockyer, of the *Albion,* says: "In comparison with other ships, which were all near us at times, I consider her behaviour equally as good as any of them, and they all appeared to roll equally as deep, though I think she rolls rather quicker than the *St. Vincent, Queen, Trafalgar,* or *Rodney*."†

On the 27th October, "the wind being light, with a rolling swell from the westward, the squadron were kept under low sail. At 10h. 35m. signal to the *Albion, Rodney,* and *Superb,* to denote extremes of rolling by pendulum:—

"*Albion* made 15° to starboard and 16° to port.
"*Rodney* made 9° to starboard and 7° to port.
"*Superb* made 9° to starboard and 10° to port.
"*Canopus* made 10° to starboard and 11° to port.

"Although the *Albion's* report of oscillation is greater than the other ships, it is not apparently more than the *Canopus* and *Superb*. It is the quickness of the *Albion's* motion which is remarkable."*

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* Letter from captain R. F. Rowley to rear-admiral sir Samuel Pym, 15th Oct., 1845.

† Letter from captain Nicholas Lockyer to rear-admiral sir Samuel Pym, 15th Oct., 1845.

To the same purpose, captain Edward Collier, of the *Rodney*, writes: "The *Rodney* can fight and work her lower-deck guns well, and has shipped but little water in any of the different exercises during the cruise; her extreme rolling has been 27°, while that of the *Albion*, *Vanguard*, and *Superb*, I hear, has been from 40° to 45°."† Of the motions of the *Superb*, captain Corry says: "Her rolling is quick, and, in proportion to the *Canopus*, as about three to two, which, in light airs, with any swell whatever, renders her very unsteady; and, it is difficult, under such circumstances, to take accurate aim with the guns. With the sea or swell on the beam or quarter, she rolls considerably, but, whether deeper than other ships, I have no means of judging. Her motion, when right before the sea or swell, is very trifling."‡

At the conclusion of the trials, captain Lockyer reports the same relative character of the *Albion*. "In comparison with other ships, I consider her behaviour equally good; they may not roll quite so quick, but they roll quite as deep to appearance."||

The relative capabilities of sailing were somewhat changed in the latter series of trials, made under the command of captain G. W. Willes. The *Superb* was re-coppered; and, instead of being always a beaten ship, as at first, she was often the fastest ship in the squadron. But, as it regards the state of the bottom, she was experiencing the highest possible advantage, whilst some of the other ships had to compete, having their copper foul and in a bad condition. The *Vanguard* also was re-coppered within the period of the trials, and, therefore, had a like accidental advantage with the *Superb*. On the contrary, captain Fairfax Moresby reports of the *Canopus*, that "the sheets of copper, some off, and in parts much crumpled, having been near four years on, must be considered, when bringing her in contact with the rest of the squadron.§ And, captain Willes says: "To their lordships' yielding to my request, when I was last at Portsmouth, to allow me additional ballast, and to the new coppering, I attribute the improved sailing of this ship; in fact, such an entire change has taken place in her motion at sea, steering and working generally (although she is still deficient in her weights low down), that I can scarcely bring myself to believe she is the same ship."¶

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* Report from captain Fairfax Moresby, H. M. S. *Canopus*, to the Secretary of the Admiralty, 28th Oct., 1845.

† Report from captain Edward Collier to admiral sir Charles Ogle, bart., 10th Dec., 1845.

‡ Report from captain A. L. Corry to admiral sir Charles Ogle, bart., 18th Dec., 1845.

|| Letter to admiral sir John West, K.C.B., 9th Dec., 1845.

§ Letter to admiral sir John West, 10th December, 1845.

¶ Report from captain G. W. Willes, of the *Vanguard*, to the secretary of the Admiralty, 17th November, 1845.

There is scarcely any occasion to draw an inference from the details of these experiments. With an honourable emulation in each captain to develop all the powers of performance of his ship respectively, it hardly strikes one as an unexpected feature of some of the reports of them, that the characteristics of inferiority are evidently palliated, and spoken of with reserve; whilst the features of excellence are placed in such prominence, as to throw a shadow over the others. Considering, now, the object which is contemplated in these experiments, it cannot be too fully understood that any palliation of bad qualities, or any exaggeration of excellence, tends necessarily to the subversion of the object for which these expensive trials are made. There is generally a great deficiency in reporting the details of the ships' performances: one case may serve as an illustration. In captain Moresby's report, already quoted as to the rolling of the squadron on the 27th of October, he says, "*Superb* made 9° to starboard and 10° to port. *Canopus* made 10° to starboard and 11° to port." Of course, the *Superb* seems to have had the advantage, in the smaller amount of rolling. But, captain Corry says the oscillations of the *Superb* were to those of the *Canopus* "as about three to two." This fact, of the *quickness* of rolling, inverts the order of relative superiority; for, the amount of rolling of the two ships was, *Superb* to *Canopus*, about as fifty-seven to forty-two.

The question might be asked, What is the intrinsic value of experiments so conducted, and so reported? And such a question might have been left open to free inquiry, had it not already received a practical answer in the conduct of the British government. But immediately after the papers relating to these experimental cruises were laid before Parliament, the lords of the Admiralty deemed it proper to guard the future construction of ships with more care than it had been hitherto, by referring all designs for ships to a board of naval construction; and the result of this arrangement soon showed itself in the setting aside of all plans similar to what was supposed to have produced the highest excellence; as the *Queen* was said to be "perfect in all points."*

When the *Raleigh*, 50-gun frigate, was commissioned for sea in 1846, her captain, sir Thomas Herbert, was ordered to try her powers of sailing, in relation to that of the *Superb*, *Brilliant*, *Vanguard*, and *Canopus*. On the 30th of May, the wind being moderate and steady, and the water smooth, the *Superb* and *Raleigh*, under all sail, began a running trial, at 9 h. 15 m. a.m., and closed it at 15 m. p.m. In this period of three hours, the *Raleigh* beat the *Superb* 1340 yards. Her angles of rolling were from 10° to 12°, and rate of sailing from six to seven knots. On the same day they tried their comparative powers of sailing to windward, under all plain sail, except the royals and flying-jib. In two hours, the *Raleigh* made one more tack than the *Superb;* and beat her 1000 yards to windward. Her rate of sailing was from four to six knots, and angle of inclination 3° to 5°.

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* Report of captain G. W. Willes to admiral sir Charles Ogle, 17th October, 1845.

On the 19th of June, with a very light wind and smooth sea, the *Raleigh* began her trial with the *Brilliant*, under all plain sail, at 2 h. 15 m. p.m.; and in three hours and 7 minutes, she gained 1792 yards to windward.

On the 20th of the same month, she tried with both the *Superb* and the *Vanguard.* The wind was light and steady, and all plain sail set. The trial began on the part of the *Raleigh* and *Superb* at 9 h. 24 m. a.m.; and at 9 h. 29 m. on the part of the *Vanguard.* At 4 p.m. it terminated, when it was found that the *Raleigh* had gained 7880 yards, that is ·688 of a mile an hour to windward, with regard to the *Superb*, having made two tacks less than she. She gained on the *Vanguard* 6012 yards, being more than half a mile an hour directly to windward.

On the 24th, the *Raleigh* was ordered to try her comparative rate of sailing to windward, with the *Vanguard* and *Canopus.* There was a strong breeze, squally weather, and a rough head-sea. At 1 h. 50 m. p.m. the trial began. Her rate of sailing was then 6·5 knots; and in 57 minutes afterwards, it was ten knots; and the inclination was from 10° to 10½°. At 2 h. 15 m. the *Raleigh* carried away her martingale, and, in consequence, took in her jib and fore topgallant-sail. It was then shown by the angles taken, that she had gained to windward on the *Vanguard* at the rate of $\frac{4}{10}$ of a mile, and on the *Canopus* at the rate of $\frac{57}{100}$ of a mile an hour. The *Vanguard* carried single-reefed topsails, main and mizen topgallant-sails, driver, jib, and second jib; the *Canopus* carried single-reefed top-sails, topgallant-sails, jib and driver; and the *Raleigh* was under double-reefed topsails, topgallant-sails, jib and driver.

In the month of August, several trials of sailing were made by the frigates. On the 9th, the *Spartan*, of twenty-six guns, built on the plan of sir William Symonds, and *Eurydice*, of the same class, built on the plan of vice-admiral the honourable George Elliot, C.B., were sailing close-hauled, nearly 5½ hours, with a light breeze, under all plain sail, royals and jib. The *Eurydice* was the faster sailer, whilst the *Spartan* was the more weatherly. The result was in favour of the *Spartan*, she having beaten the *Eurydice* nearly half a mile to windward. On the 10th the same frigates tried again, the wind being about a point free. There was a moderate breeze, and the vessels were under all plain sail, royals and flying jib, going about seven knots; and in about three hours and ten minutes the *Spartan* gained a mile on the *Eurydice.*

On the 11th, the frigates being under all plain sail, except royals, another trial was made in working to windward. In four hours the *Eurydice* beat the *Spartan* about 900 yards to windward; and in the same time the *Raleigh* weathered on the *Constance* 2760 yards.

On the 20th, a more general competition took place, under the orders of vice-admiral sir William Parker, who reported the various performances of the several ships as follows :—*

" The weather continuing favourable, and the wind strong, I sent the *Eurydice* fifteen miles dead to leeward, and at 11 h. 15 m. a.m. started the *Vanguard, Canopus, Raleigh,* and *Constance* together, to pass round her stern, and the whole to beat back to the flag-ship. They passed the *Eurydice* successively in the order stated in the accompanying return, and rejoined the squadron in the order which is also stated therein. All the ships displayed excellent sailing qualities and stability, but the advantage was certainly with the *Raleigh,* followed closely by the *Eurydice.* It is, however, right to observe, that the *Constance* having run before the wind with all her reefs out, lost ground considerably in reefing her topsails. †

" *Summary of Reports of Trial of Sailing between the undermentioned Ships,* 19*th August,* 1846.

Eurydice beat	*Yards*	*Spartan beat*	*Yards*	*Constance beat*	*Yards*	*Vanguard beat*	*Yds.*	*Canopus beat*	*Yds.*	*Rodney beat*	*Yds.*	*Albion beat*	*Yds.*
Spartan ..	1153	Constance	633	Vanguard.	8400	Canopus ..	660	Rodney.	2900	Albion ..	1160	Queen ..	2340
Constance	1786	Vanguard.	9033	Canopus.	9060	Rodney ..	3560	Albion ..	4080	Queen ..	3520		
Vanguard.	10186	Canopus ..	9693	Rodney ..	11960	Albion ...	4740	Queen ..	6420				
Canopus ..	10846	Rodney ..	12593	Albion ...	13140	Queen	7080						
Rodney ..	13746	Albion ...	13773	Queen	15480								
Albion	14926	Queen	16113										
Queen	17266												

One more trial was made before the frigates separated, and it is thus reported : in " the afternoon of the 27th instant, the *Rattler* was sent five leagues in the wind's eye of the *Hibernia,* and the whole squadron directed to beat up to her, and pass her to windward, leaving the captains at liberty to act as they considered most advantageous.

" The wind not being stronger than to admit an average rate of six knots and a half per hour, the ships carrying royals with all reefs out of the topsails, five only succeeded in passing to windward of the *Rattler* before dark, and these weathered her in the following order : 1 *Raleigh,* 2 *Constance,* 3 *Spartan,* 4 *Eurydice,* 5 *Superb.* ‡

" Some advantage was gained by the ships which stood nearest in shore, getting for a time a favourable slant. I consider, however, that the *Raleigh* had but a slight advantage over the *Constance.* The *Eurydice* and *Spartan* sailed nearly alike, proving themselves almost equal to the larger frigates.

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* Despatch from vice-admiral sir William Parker, bart., G.C.B., to the secretary of the Admiralty, 22nd August, 1846.

† The advantage the *Constance* had over the other ships in running down with more sail, must have been at least equivalent to the loss she sustained in reefing the topsails ; and doubtless it was expected that, on the whole, *something would be gained.*

‡ See Return to the House of Lords, No. 335, session 1848.

" Of the line-of-battle ships, the *Superb* excelled. The *Vanguard* and *Canopus*, which were next in priority, appeared on a par. The *Albion* took the lead of the *St. Vincent*, weathering on her altogether 950 yards; and the *St. Vincent* weathered on the *Queen* 1550 yards. The *Rodney* was inferior to all but the *Hibernia*, which, at sunset, was sixteen cables' lengths to leeward of that ship." *

The trials of sailing between the *Raleigh* and the *Constance*, a frigate of the same class, constructed by sir William Symonds, extended over a considerable period. And as the course of competition is very concisely and ably described by sir Thomas Herbert, the following quotations are made from his letter of the 29th September, 1846 :

" The *Constance* and *Raleigh* have been nearly two months together, and have had almost all kinds of weather and winds, and have had trials in all points of sailing. On our passage from off Lisbon to the tropic of Capricorn, we have had, occasionally, light, variable, and fresh breezes, and strong and steady trades, *so steady*, that for days we have had no occasion to touch a brace. Frequently the *Raleigh* had to shorten sail, and heave to, for the *Constance* to come up, and scarce a day that the *Raleigh* did not run ahead of her several miles; and on two occasions she was left half courses and hull down astern.

" During the short time the *Raleigh* has been in commission, she has been over one hundred days at sea, and has experienced some rough as well as smooth weather, though actually not a very strong gale; and I never was in a drier or easier ship, or one that strained her rigging less. She steers well, stays and wears quickly; she scarce can be put out of trim, for whether she is a few inches by the head or the stern, or with *five* or three months' provisions, it seems to make no difference in her sailing. I consider she does best in the builder's trim; and I cannot find out anything in the ship that requires altering. She stows five months' provisions, and 240 tons of water, with the greatest ease; has wings round her. But if that part of the after-hold, taken off for the wings, were to be thrown into it, as they are in the *Constance*, she could then stow nearly six months,—not that I should recommend the wings to be thrown into the after-hold. Taking the ship as a whole, I do not believe a more perfect man of war was ever built."

One can hardly go through a comparison of the reports of officers commanding rival ships, in experimental sailing, and retain his confidence that all of them were written with perfect impartiality. The captain of the *Constance*, sir Baldwin W. Walker, in his report, dated the 29th September, 1846, says,—"I am of opinion that, before the wind, the *Raleigh* has had the advantage of the *Constance*, but with the wind abeam and abaft it, the *Constance* has had the advantage of the *Raleigh*. On a wind, the *Constance* is more weatherly, but the *Raleigh* fore-reaches. And, on the whole, as far as the trials have gone, I am of opinion that both ships are nearly as equal as possible. There has been no trial with less sail than single-reefed topsails, topgallant-sails, courses, jib, and spanker; and although the ships have not had much of a trial against a head-sea, judging from what I have observed, I am of opinion that the *Constance* would have greatly the advantage of the *Raleigh*. Generally speaking, the winds have been light and variable since we left the squadron; and in consequence of the great distance the two ships have been occasionally apart, it is difficult to decide which is the best sailer."

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* Despatches from vice-admiral sir W. Parker, to the secretary of the Admiralty, 29th August, and 2nd September, 1846.

The daily records of the relative performances of the two ships, leave no room whatever now, to doubt which was the better sailer.* This may have been uncertain, as it regards the run from Lisbon to Madeira; for the difference was only four miles out of 500, in favour of the *Raleigh*. On the 28th of August, the report of the *Constance* says: "Gained considerably on *Raleigh between* 11 *and noon*, running with the wind abeam, with starboard studdingsails set." The wind was then on the quarter. At night the *Raleigh* gained eight miles on the *Constance*, an advantage which was lost on the 29th, the wind varying about two points. The *Raleigh's* report says: "Wind rather variable and light during part of this day *Constance* apparently bringing up the breeze. Both ships under all possible sail." On the 30th, the advantage was again on the part of the *Raleigh*, when they both arrived at Madeira.

From the time when the frigates left Madeira, till they passed the tropic of Capricorn, occupying a period of twenty-five days, the *Raleigh's* report states that on one morning the *Constance* had the advantage in sailing; but no such statement is repeated. During this time there were trials of sailing with the wind right aft, nearly aft, on the quarter, two or three points abaft the beam, nearly abeam, one point free, and for seven days successively they were sailing by the wind. On six of these days the *Raleigh* had the advantage, and on the other day, the frigates were nearly equal. During the greater part of one other day, the wind being nearly abeam, there was no difference in the sailing of the two ships. The *Raleigh* had to shorten sail *ten times* during these twenty-five days, to allow the *Constance* to come up; besides at various other times, carrying less sail than the *Constance*, still having the advantage of her. Several days passed, subject to calms and light variable airs, which allowed no opportunity of trying the sailing powers of the ships; on one of these days, however, September 16, *Constance's* report says: "During the forenoon, light variable winds, with a head swell. Lowered royals, and hauled up the mainsail to keep our station. Head sea: *Raleigh* has no chance with *Constance*. Rate of sailing, one and two knots."

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* They have been made public through the medium of the House of Lords.

In the trials of sailing between the *Superb*, 80-gun ship, constructed by sir William Symonds, the *America*, a 50-gun razée (formerly a 74-gun ship), built in 1810, after a design by the surveyors of the navy, and the *Thetis*, 40-gun frigate, designed by Messrs. Read, Chatfield and Creuze, a striking difference was exhibited by the two principal ships, the *Superb* and the *Thetis*, resulting from a cause inherent in the ships. The inferiority of the *Superb* was the most fully exhibited in sailing close-hauled, with a head-sea; but this became less, as the course of the ships was such, that they received the swell upon the quarter instead of the bow. The relative sailing qualities were tried on several occasions, and under several conditions of wind and sea. On the 1st of March, 1847, the trial was with the wind abeam, and a long swell. In these circumstances the *Thetis* beat the *Superb*, at the rate of 2500 yards an hour; the *America* was second, gaining a considerable advantage over the 80-gun ship. But in the course of the trial, the swell materially decreased, and the comparative rates of sailing were altered; the *Thetis* continued to gain then at the rate of only 700 yards an hour; and the *America* became the third ship.

On the next day, a trial took place, close-hauled, with a fresh breeze. When the swell was on the weather-quarter, the *Superb* beat the frigates considerably to windward; but when, on the opposite tack, the swell was upon the bow, the *Thetis* beat the *Superb*. During the whole trial, which lasted 5h. 25m., the *Thetis* beat the *Superb* 3000 yards, and the *America* 3840 yards directly to windward. The *Superb* sustained some disadvantage by splitting her fore-topsail, which was then lowered for more than half an hour.

The next trial was in sailing one point free, with a fresh breeze and smooth sea. In about 2h. and 20m., the *America* beat the *Superb* 1280, and the *Thetis* beat her 850 yards. The wind afterwards changed and was very light, with a slight following swell, which turned the advantages; for, during about three hours in which the trial was continued, the *Superb* gained on the *Thetis* 600 yards, and 1200 on the *America*.

A second trial of sailing close-hauled, was made on the 8th. The three ships carried single-reefed topsails, courses, fore and main top-gallantsails, jib, and single-reefed spanker. "During the first hour, the *Thetis* beat the *Superb* nearly 400 yards to windward;" but the wind then changed, and brought the swell more aft, when "her gain was greatly diminished." There was but little difference in the sailing of the *Superb* and the *America*. In continuing the trial, the *Thetis* beat at the greatest rate as there was a head sea, and at the least rate as the swell was more aft. And in the period of 4h. and 12m., the *Thetis* beat the *Superb* 5230, and the *Superb* beat the *America* 3930 yards directly to windward.

The trial on the 9th, was in running before a strong breeze, with a long swell, under all plain sail, except the jib and spanker. In the course of 7h. they sailed through a space of fifty-nine miles; while the *Superb* and *America* were nearly equal, the *Thetis* gradually gained on the *Superb*; and her ultimate advantage was about 3200 yards.

The three remaining trials were on a wind. On the 13th, the ships were under all plain sail, and there was a slight swell on the weather-quarter. After sailing 1¾h., the ships wore together, occupying respectively the following times:—*Superb* 5m. 40s., *America* 5m. 54s., and *Thetis* 6m. 4s. But, in the course of wearing, the *Thetis* gained 460 yards on each of the other ships;* and in 1h. 25m., on the port tack, she gained 785 yards on the *Superb*; and this ship gained 150 yards on the *America*.

On the 26th of March, as well as on the 30th, the *America* did not join in the trial. On the first of these days, it included exercising the guns, as well as sailing. "During the forty-five minutes we were on the starboard tack, the *Superb* gained 520 yards on the *Thetis*;" but "during the 3 hours and 45 minutes which the trial lasted, the *Thetis* gained to windward of the *Superb* 1650 yards." The time in which the *Superb* gained her advantage, was when the swell was on the quarter.

"March 30th, at 9h. 20m. A.M., the signal was made to try rate of sailing on a wind, and for the *Thetis* to carry the same sail as the *Superb*. There was a light breeze from the N.E. by E., varying through the trial, in strength, from a two-knot to a five-knot breeze; and in direction nearly two points; and a slight swell from N.N.E. The *Thetis* went rapidly past the *Superb*, and continued to gain on her during the day, in a greater proportion than in any previous trial. At 1h. 20m., the ships broke off three points; the angles were immediately taken, and the recal made, the trial having lasted three hours, during which time the *Thetis* beat the *Superb* 2810 yards to windward."

In the following November, the *Thetis* was again tried with several ships of the line,—as the *Vanguard*, *Superb*, *Albion*, *Rodney*, *Hibernia*, and *Trafalgar*. On the 9th of that month, the trial was in going free, with a moderate and steady wind, and a smooth sea, under all plain sail, and starboard or port studdingsails, according to the tack. The *Thetis* gained on the *Vanguard* at the rate of 850 yards an hour,—on the *Superb* at nearly double that quantity,—on the *Albion*, 1960 yards,—on the *Rodney*, two miles,—and on the *Hibernia* and *Trafalgar*, a little more.

The four other trials were in sailing close-hauled. On the first of these there was a fresh steady wind; and all plain sail, except the royals, was carried. At the beginning, the sea was rather rough; but it became more moderate during the time of the trial. In 5h. 30m., the *Thetis* beat the *Superb* at the rate of 1363,—the *Albion* 1818,—the *Vanguard* 2418,—the *Trafalgar* 2654,—the *Rodney* 2727,—and the *Hibernia* 3000 yards an hour, "dead to windward." In this trial, the *Vanguard* sustained some disadvantage by the splitting of her fore-topsail. On the 13th, the wind was light and variable, and the sea smooth: a trial of sailing close-hauled took place, lasting 6h. 50m. The *Thetis* weathered directly on the other ships as follows: on the *Vanguard* 776 yards,—the *Albion* 1080,—the *Superb* 1340,—the *Hibernia* 1570,—the *Trafalgar* 1676,—and the *Rodney* 1760 yards per hour. On the 15th, the *Thetis* beat her two competitors, the *Albion* and *Superb*, in a rather greater degree, the wind being moderate and variable, and the sea smooth. The last trial included the *Rodney* also, and lasted 6h. 20m. The *Thetis* now beat the *Albion* 685,—the *Superb* 1000,—and the *Rodney* 1530 yards an hour, dead to windward.* And sir William Parker says, "The *Thetis* appears to answer in all respects admirably, and, I understand from captain Codrington, is not easily put out of trim."

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* The advantage gained by the *Thetis* in this manœuvre, was deemed so extraordinary at the time, that the officer who was taking the angles of bearing, distrusted the accuracy of his observation, and called the master of the ship to verify it.

In connection with the performances of experimental squadrons, the claims of amateur naval constructors are brought before the public. If it were a subject of inquiry, What benefit has the country ever derived from what they have done?—it might be difficult to find a positive answer. Indeed, it is not easy to identify their performances with any merit which the good character of a ship they may have been the means of introducing into our navy might generally seem to imply. It is not to be expected that men without professional education can become naval architects; whilst it would be absurd to suppose that observing naval officers may not gain valuable ideas on this subject. But what is the condition in which their opinions are evolved? Undoubtedly much more in that of disjointed notions, than as parts of a system exhibiting their dependences and relations in regular order. This seems to be inevitable; since the relations of the various conditions cannot be understood without study,—a study embracing the elements, as well as the general conditions, and the outline.

What is now the effect of constructing ships with so special a reference to a particular condition of form or dimensions? Has it been a tendency to general improvement? It is clear that the partiality which includes more of one property than is consistent with the conditions of general excellence, is carrying alterations in an unfortunate direction,—it is going backwards. This course of proceeding is essentially erroneous, as it is at variance with the principles which both science and experience have proved to be true. As amateur constructors do not hold their notions in deference to any system of principles, so they are at a loss how to remedy defects:* and for the want of a correct knowledge of general principles, there is no prospect for that which is left to their hands, but perpetual error;—a very grave fact, which needs no more illustration than many of the ships in the British navy now supply.

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* Report of vice-admiral sir William Parker, 18th November, 1847.

It cannot fail of being very useful to the scientific constructor, to have all the elements of the body shown in a general relation to each other, and compared with experimental data. He will be thereby essentially aided in drawing conclusions, as to the relation the general elements bear to the performances of ships. And the more experimental sailing is made with the simple view of marking the relative qualities quite distinctly, and irrespectively of successful competition, the more useful will it be in improving the science of ship-building; since it is from actual experience that general principles are to be deduced, and laws established for building ships with growing certainty of success.

There are some relations of the elements of bodies, in which ships should be compared together, in reviewing the results of their trial-sailing, and there are also various conditions in which they should be subjected to comparison,—as the trim of the ship, the position and trim of the sails, and several others; for it is well known, that the good or bad sailing of a ship depends on many causes: and, therefore, apart from such general comparison, much is often left to mere conjecture, as to what are the true conditions of character. A plan for developing the highest powers of performance in ships intended to be tried in competition, is elsewhere suggested. If that were acted on, and the results of their sailing and other capabilities compared in connection with the relations of their elements, improvement might be confidently expected to follow. With the view to guide and facilitate such comparisons, the following elements of ships, that have been already tried, are presented.

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* When captain Hayes first appeared as the constructor of a ship of war, he made the after-body fuller, in comparison with the fore-body, than that of most other ships in the navy. But on finding the effect of this error, he afterwards formed the design for a ship, having one of the *smallest* relative after-bodies. On the contrary, captain Symonds built his first experimental ship with the after-body remarkably small, in relation to the fore-body. *He* also passed into the opposite extreme; and in a future experiment he gave a greater relative fulness to the after body than most other ships possessed. If the principles on which the adjustment of the body of a ship is determined, had guided the constructor in either of these cases, he might surely have avoided the error of giving an *excessive* relative fineness or fulness to either extremity of his ship.

Elements of Construction of Experimental Ships.		*Espiègle.*	*Flying Fish.*	*Mutine.*	*Daring.*	*Osprey.*	*Cruizer.*	*Sapphire.*
Length on the water-line, from the fore part of the stem to the after part of the stern post, in feet and inches		105 3	102 2	101 4	104 2	100 10	99 8	119 9
Breadth extreme, to the outside of the planking, in feet and inches		31 6½	32 0½	31 6	31 0¼	31 6¼	30 8¾	33 8
Relation of length to breadth, at the water-line		3.34	3.18	3.21	3.35	3.2	3.25	3.55
Draught of water, in feet and inches	Forward	12 9	13 6	12 8	12 5	12 2	12 4	14 6
	Aft	14 9	14 7	14 2¼	16 9½	15 1	14 10	15 6
Mean draught of water in relation to the extreme breadth, in feet		.434	.44	.427	.474	.431	.444	.444
Height of lower port-sills, in feet and inches		5 0	3 10	4 9	4 5	4 6	4 4	5 4
Depth of keel and of false keel below the rabbet of the keel, in feet and inches		1 3	1 0	1 1	1 4	1 0	1 6	1 5
Distance of the greatest transverse section before the middle of the length of the water-line, in terms of the length of the water-line, in feet		.010	.06	.059	.067	.056	.041	.070
Distance of the centre of gravity of displacement before the middle of the water-line, in terms of the length of the water-line, in feet		.013	.012	.016	.018	.013	.015	·016
Circumscribed rectangular parallelopipedon, contained by length on the water-line, breadth on the water-line, and mean draught of water, in cubic feet		45456	46112	42800	47115	43193	41554	56498
Displacement in terms of the said parallelopipedon, in cubic feet		.377	.374	.394	.396	.395	.405	.470
Area of the circumscribed rectangle contained by the breadth at the water-line, and depth from the water-line to the lower side of the rabbet of the keel, in square feet		394.2	419.2	387	410.7	396.9	370.9	471.8
Area of the greatest transverse section in terms of the said rectangle, in sq. ft.		.592	.606	.622	.685	.633	.671	.658
Area of the circumscribed rectangle contained by the length and breadth at the water-line. in square feet		3318	3270	3194	3227	3176	3055	4035
Area of the load-water section in terms of the said rectangle, in square feet		.781	.761	.801	.77	.785	.805	.897
Depth of the centre of gravity of the greatest transverse section in terms of the mean draught of water, in feet		.296	.333	.322	.346	.322	.336	.375
Distance of the centre of gravity of the load-water section from the middle of the water-line, in terms of its length, in feet		.002 abaft	.006 abaft	.003 before	.001 before	.02 before	.001 before	.0025 before
Moment of stability at 10° inclination, in tons		510	418	475	291.9	423.5	422	847
Height of the centre of effort of the sails, in feet		46.9	45.9	47.2	46.9	47.0	45.6	58.02
Distance of the centre of effort of the sails before the centre of gravity of displacement in relation to the length of the load-water line, in feet		.001	.000	.001 abaft	.044 abaft	.03 abaft	.002	.040
Relation of the moment of sail that is abaft the centre of gravity of displacement to the moment of sail that is before the said centre		.99	1.0	.90	1.1	1.0	.9	.76
Moment of the sails in terms of the stability		908	1082	993	1270	1100	1070	933
Area of the sails in relation to the area of the midship section, in square feet		43.5	39.5	41.6	35.6	40.0	39.8	43.9
Area of the sails in square feet, in relation to the displacement in cubic feet		.58	.57	.59	.53	.58	.58	.512

ELEMENTS OF CONSTRUCTION OF EXPERIMENTAL SHIPS.	*Acorn.*	*Columbine.*	*Wolf.*	*Pylades.*	*Orestes.*	*Champion.*	*Calliope.*
Length on the water-line from the fore part of the stem to the after part of the stern-posti in feet and inches	111 5	104 5	112 6	109 0	112 11	112 6	131 6
Breadth extreme, to the outside of the planking, in feet and inches	30 6	33 2	30 9	30 0	30 6	30 9	35 0
Relation of length to breadth at the water-line	3.65	3.24	3.65	3.63	3.7	3.65	3.75
Draught of water, in feet and inches { Forward	14 0	13 9	14 7	12 4	12 6	14 7	15 6
Draught of water, in feet and inches { Aft	15 0	15 0	14 7	13 6	14 1	14 7	16 5
Mean draught of water in relation to the extreme breadth, in feet	.476	.434	.470	.422	.436	.474	.454
Height of lower port-sills, in feet and inches	5 0	4 0	5 7	5 8	5 7	5 7	6 4
Depth of keel and of false keel below the rabbet of the keel, in feet and inches	1 6	1 3	1 7	1 4	1 4	1 7	1 4
Distance of the greatest transverse section before the middle of the length of the water-line, in terms of the length of the water-line, in feet	.090	.097	.066	.092	.073	.066	.068
Distance of the centre of gravity of displacement before the middle of the water-line, in terms of the length of the water-line, in feet	.017	.019	.012	.017	.019	.012	.023
Circumscribed rectangular parallelopipedon, contained by length on the water-line, breadth on the water-line, and mean draught of water, in cubic feet	49266	45405	44971	37605	41149	44971	73217
Displacement in terms of the said parallelopipedon, in cubic feet	.426	.393	.473	.488	.454	.473	.431
Area of the circumscribed rectangle contained by the breadth at the water-line, and depth from the water-line to the lower side of the rabbet of the keel, in square feet	396.5	434.9	430.5	345.0	364.4	430.5	511
Area of the greatest transverse section in terms of the said rectangle, in sq. ft.	.644	.586	.601	.671	.654	.601	.659
Area of the circumscribed rectangle contained by the length and breadth at the water-line, in square feet	3400	3466	3459	3270	3443	3459	4602
Area of the load-water section in terms of the said rectangle, in square feet	.843	.774	.843	.828	.824	.843	.847
Depth of the centre of gravity of the greatest transverse section, in terms of the mean draught of water, in feet	.309	.360	.358	.378	.359	.358	.333
Distance of the centre of gravity of the load-water section from the middle of the water-line, in terms of its length, in feet	.0015 abaft	.005 before	.004 before	.0073 before	.0088 before	.0010 before	.01 before
Moment of stability at 10° inclination, in tons	462	542	513.4	455.3	535.7	513.4	902
Height of the centre of effort of the sails, in feet	47.32	43.8	48.5	47.7	48.32	48.5	59.3
Distance of the centre of effort of the sails before the centre of gravity of displacement, in relation to the length of the load water-line, in feet	.028	.025	.057	.069	.022	.057	.054
Relation of the moment of sail that is abaft the centre of gravity of displacement to the moment of sail that is before the said centre	.70	.61	.65	.65	.86	.63	.77
Moment of the sails in terms of the stability	1130	773	1033	1065	983	1033	810
Area of the sails in relation to the area of the midship section, in square feet	43.2	37.4	42.4	44.0	45.5	42.4	37.6
Area of the sails in square feet, in relation to the displacement in cubic feet	.525	.530	.514	.553	.582	.514	.40

ELEMENTS OF CONSTRUCTION OF EXPERIMENTAL SHIPS.	*Vestal.*	*Electra.*	*Inconstant.*	*Castor.*	*Pique.*	*Barham.*	*Vernon.*
Length on the water-line from the fore part of the stem to the after part of the stern-post, in feet and inches	132 6	112 11	161 7	159 8	162 1	177 0	177 3
Breath extreme, to the outside of the planking, in feet and inches	40 3½	30 6	45 4	42 8	48 3	48 4	52 0½
Relation of length to breadth at the water-line	3.28	3.7	3.56	3.74	3.35	3.66	3.40
Draught of water in feet and inches { Forward	16 10	12 6	18 8	18 0	19 6	20 6	21 0
Aft	17 11	14 1	19 3	19 6	20 6	20 6	22 0
Mean draught of water in relation to the extreme breadth, in feet	.431	.436	.417	.446	.414	.424	.413
Height of lower port-sills, in feet and inches	5 7¼	5 7	7 3	7 10	8 0	8 1¼	8 9
Depth of keel and of false keel below the rabbet of the keel, in feet and ins.	1 0	1 4	1 4	1 8	1 1½	2 9	1 3
Distance of the greatest transverse section before the middle of the length of the water-line, in terms of the length of the water-line, in feet	.115	.073	.072	.056	.04	.034	.099
Distance of the centre of gravity of displacement before the middle of the water-line, in terms of the length of the water-line, in feet	.025	.019	.020	.014	.010	.021	.019
Circumscribed rectangular parallelopipedon, contained by length on the water-line, breadth on the water-line, and mean draught of water, in cubic feet	92646	41149	138448	129410	156426	175365	198165
Displacement in terms of the said parallelopipedon, in cubic feet	.419	.454	.440	.475	.424	.503	.442
Area of the circumscribed rectangle contained by the breadth at the water-line, and depth from the water-line to the lower side of the rabbet of the keel, in square feet	659	364	797.2	739.2	912	857.8	1053
Area of the greatest transverse section, in terms of the said rectangle in sq. ft.	.646	.654	.660	.722	.60	.797	.630
Area of the circumscribed rectangle contained by the length and breadth at the water-line, in square feet	5339	3443	7325	6811.0	7821	8554	9217
Area of the load-water section, in terms of the said rectangle, in square feet	.834	.824	.820	.845	.825	.856	.844
Depth of the centre of gravity of the greatest transverse section, in terms of the mean draught of water, in feet	.345	.359	.370	.356	.35	.38	.353
Distance of the centre of gravity of the load-water section, from the middle of the water-line, in terms of its length, in feet	.023 before	.008 before	.006 before	.005 before	.001 before	.022 before	.002 before
Moment of stability at 10° inclination, in tons	1420	535	2220	1920	2786.9	3398	3715
Height of the centre of effort of the sails, in feet	62.3	48.3	70.53	74.0	70.48	76.5	77.2
Distance of the centre of effort of the sails before the centre of gravity of displacement, in relation to the length of the load-water line, in feet	.27 abaft	.022	.042	.050	.028	.019	.003 abaft
Relation of the moment of sail that is abaft the centre of gravity of displacement to the moment of sail that is before the said centre	1.0	.87	.82	.73	.91	.87	1.0
Moment of the sails in terms of the stability	620	983	618	810	500	547	504
Area of the sails in relation to the area of the midship section, in square feet	33.1	45.5	37.2	39.0	35.8	35.5	36.3
Area of the sails in square feet, in relation to the displacement in cubic feet	.363	.58	.322	.338	.297	.275	.277

ELEMENTS OF CONSTRUCTION OF EXPERIMENTAL SHIPS.	*Raleigh.*	*Constance.*	*Bellerophon*	*Vanguard.*	*Caledonia.*	*Queen.*	*Albion.*
Length on the water-line from the fore part of the stem to the after part of the stern post, in feet and inches	181 6	182 0	194 2	188 0	207 4	204 7	205 0
Breadth extreme, to the outside of the planking, in feet and inches	49 6	52 2¾	49 0	56 0	54 6	59 2½	59 4½
Relation of length to breadth at the water-line	3.66	3.48	3.96	3.35	3.8	3.45	3.45
Draught of water, in feet and inches { Forward	20 8	20 11	20 9	22 8	24 9	24 6	23 5
Draught of water, in feet and inches { Aft	21 8	22 8	22 6	23 0	26 0	26 0½	25 3
Mean draught of water in relation to the extreme breadth, in feet	.428	.417	.44	.407	.466	.426	.41
Height of lower port-sills, in feet and inches	9 7	9 1½	6 2	7 5	5 2½	6 8	6 2
Depth of keel and of false keel below the rabbet of the keel, in feet and inches	1 6	1 7	1 8	1 3	2 4	1 9	1 0
Distance of the greatest transverse section, before the middle of the length of the water-line, in terms of the length of the water-line, in feet	.086	.086	.035	.085	.057	.057	.061
Distance of the centre of gravity of displacement before the middle of the water-line, in terms of the length of the water-line, in feet	.016	.002	.005	.009	.005	.003	.003
Circumscribed rectangular parallelopipedon, contained by length on the water-line, breadth on the water-line, and mean draught of water, in cubic feet	190106	207029	205541	241091	287006	305836	296017
Displacement in terms of the said parallelopipedon, in cubic feet	.473	.429	.557	.494	.562	.538	.516
Area of the circumscribed rectangle contained by the breadth at the water-line, and depth from the water-line to the lower side of the rabbet of the keel, in square feet	973.4	1054	976	1209	1255	1391	1384
Area of the greatest transverse section, in terms of the said rectangle, in sq. ft.	.679	.63	.806	.681	.817	.76	.713
Area of the circumscribed rectangle contained by the length and breadth at the water-line, in square feet	8984	9496	9515	10528	11299	12112	12166
Area of the load-water section, in terms of the said rectangle, in square feet	.851	.805	.895	.875	.868	.873	.864
Depth of the centre of gravity of the greatest transverse section, in terms of the mean draught of water, in feet	.345	.341	.389	.359	.374	.382	.374
Distance of the centre of gravity of the load-water section, from the middle of the water-line, in terms of its length, in feet	.204 before	.137 abaft	.002 abaft	.000	.004 abaft	.002 abaft	.004 abaft
Moment of stability at 10° inclination, in tons	3455	3786	2943	5655	2812	5864	7292
Height of the centre of effort of the sails, in feet	79.0	78.2	82.29	84.72	85.28	91.4	86.6
Distance of the centre of effort of the sails before the centre of gravity of displacement, in relation to the length of the load-water line, in feet	.031	.005	.042	.062	.071	.054	.058
Relation of the moment of sail that is abaft the centre of gravity of displacement to the moment of sail that is before the said centre	.84	.96	.77	.73	.66	.70	.67
Moment of the sails in terms of the stability	562	497	776	417	832	461	367
Area of the sails in relation to the area of the midship section, in square feet	37.1	36.5	35.2	33.7	27.7	27.9	31.3
Area of the sails in square feet, in relation to the displacement in cubic feet	.272	.273	.24	.23	.17	.179	.202

In reviewing the history of the British navy through the greater part of the last century, we see much sound, practical knowledge, generally marking the conduct of the surveyors of the navy, in forming their designs. And the character which their ships bore, in long and arduous duties, makes the names of their several constructors to be respected in the English naval service. Apart from mathematical reasoning and investigation, to which they did not pretend, they carefully compared the various facts of experience, and cautiously and judiciously drew their conclusions. On the other hand, mathematicians have laboured in the investigation of causes, but they have generally reasoned on hypotheses instead of facts; and hence, there is scarcely a formula on any part of this science that can be applied and depended on for accurate results, with the exception of Mr. Atwood's formula for determining the stability of ships. Constructors are, therefore, still left to deduce from experience the conditions on which their designs shall be formed, both as to the resistance which ships have to overcome in passing through the water, and to the motions of pitching and rolling. Euler has, with his usual ability, investigated the resistance opposed to a ship's motion through the water, and has given a formula for calculating its amount; but Chapman says "it is the velocity of the body which ought to determine the place of the greatest breadth, in order that the resistance may be a *minimum*;" * and he deduced this result from experiments. Recent experience in the British navy has agreed with this deduction; for, in the reports of the sailing of the *Raleigh* and *Constance*, it is shown, that in light airs and very small velocities, the *Constance* always beat; but when there was a fresh breeze, the sailing power of the *Raleigh* was invariably and decidedly superior. Her greatest breadth was considerably farther forward than that of the *Constance*. Don Juan says, "Of all the theories of a ship's motions, the most complicated is, without contradiction, that of the rolling and pitching;" † and he points out the defect in the reasonings of mathematicians on this subject. These two important questions remain yet unsolved.

In the absence of formulæ, to apply in investigating the connection of cause and effect, great difficulty is necessarily felt; and there are few that have time, and patience, and means, to attempt such a work from the facts of experience. The British navy might have supplied enough of these for this purpose; but though they have been exhibited and repeated thousands of times, yet they are seldom watched and registered with sufficient exactness in the details. Thus it is, that theory and experience together leave the subject involved in uncertainty, as to many things that are necessary to perfection.

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* Traité de la Construction des Vaisseaux, &c. Par Frederic-Henri de Chapman; traduit du Suédois par M. Vial du Clairbois. Chap. iv., § 15.

† Examen Maritime, Théoretiqne et Pratique. Par Don Georges Juan; traduit de l'Espagnol par M. Levéque. Tome second, chap. vi.

Objection has been made, that ships built on the same lines have been dissimilar in their character at sea. It may be freely admitted that few things are more clearly possible. But as like causes produce like effects, it is equally clear that, if the ships are alike, such difference is owing to something else than the form. There is more than enough in the accidental conditions of ships to account for this fact; it is, then, amongst these that the causes of the difference should be sought. Although it is not an essential condition that a ship's form should be such as to make a difference of stowage (causing a difference of a few inches in her trim longitudinally) produce a sensible alteration in her sailing qualities; yet we see few ships that are not sensitive in this respect. The causes of many varied effects might be found in the differences of stowage. Further, the dissimilar relative positions of sail, whilst other things remain the same, would produce great and important differences in ships' sailing qualities and powers of evolution. If all the accidental conditions of such ships are alike, and still the qualities exhibited in their performances are unlike, then, instead of depending on the official report of their having been built on the same lines, as proof that they were really alike, it would be better to take off the bodies, and determine the question of exact resemblance, before drawing final conclusions. But, whilst the whole scope of the question is open to inquiry, it is evident that it cannot be discussed with advantage in the gross, although the character of many ships has been declared on no stricter inquiry; the question should be narrowed by discussing separately, and in detail, the various points which it includes; and, it may be, that the most satisfactory conclusions will be arrived at by such a mode of investigation.

The general observations on experimental squadrons, and trials of comparative sailing, interspersed with the narrative part of this article, leave occasion to say but little in conclusion. There remain, however, to be noticed briefly, the relative conditions of ships under trial. If the fitness of a ship's form to the state of the ocean, is to be inquired into on the ground of her sailing, or the manner in which she otherwise behaves, relatively to other ships, it seems that one of the first conditions should be, to have them *accidentally* as much alike as circumstances will allow. Let it be admitted, as a general principle, that the weights, including the armament, put on board of any ship, should bear some definite relation to the parallelopiped of her length, breath, and mean draught of water, or, in other words, to her principal dimensions; then, if ships, in their respective classes, of different form, or different relative dimensions, are in this respect brought to a standard, there is established one fair condition for comparison. It is very clear that a disregard of this condition must leave so much in a state of uncertainty, that there is not enough defined to supply such proof of the *ground* of excellence or of defect as is required in carrying on the needed improvements in naval architecture. And yet there has been scarcely anything connected with experimental sailing, within these few years, which has involved more uncertainty, as it regards the sailing and other qualities of many of the ships which have been built since the removal of the restrictions to a certain tonnage, in constructing ships of war. This fact has been noticed by rear-admiral sir Charles Napier, in respect of the *Queen;* and it was remarked on by him in a letter to the secretary of the Admiralty, dated the 29th of November, 1847: "The *Queen* is an enormous ship, and I think ought to mount ten more guns in her vacant ports; her main-deck guns ought also to be heavier.

"The *Queen* is certainly superior to other three-deckers in sailing and stability; but for her size she is underweighted, which may be easily seen by comparing the weight of her guns, powder, and shot, with her tonnage, and the same with any other three-decker; and I very much doubt whether the *Queen* would be so superior, if they were weighted in proportion to their size; it would be an experiment well worth trying."

Other conditions, claiming the like attention, are the relation of the area of sail *carried,* to the area of the greatest transverse section of the ship, and also to her displacement; these relate, of course, to her speed through the water. But there are conditions apart from the form and stowage, which affect the motions of ships; and, in order to compare them fairly, it appears necessary to try them with such reference to the parity of those conditions that, as much as the circumstances will allow, conclusions may be come to, freed from doubt as to the cause of difference: one of these is the relation of the moment of sail before the centre of gravity to that abaft this point; for it is evident, that a ship's power to hold a good wind and to stay well, must depend on the correct relation of these two forces. For this point, see the *Tables of Elements,* in which, for the several ships, the relation of the fore and after moments, with the position of the centre of effort of the sails in relation to the centre of gravity of displacement, is given; and below is shown the power of sail, given in terms of the displacement, and of the area of the greatest transverse section. The weight of the armament is likewise shown in relation to the principal dimensions, or in relation to the circumscribing parallelopipedon formed by the principal dimensions, as by it all the other weights in a ship of war are determined, and it is on showing these relations that we can form one fair condition for comparison.

In the following Table, A denotes the whole area of sails in square feet; a, the area of the midship section; D, the displacement in tons; T, the number of tons that would be displaced by a parallelopipedon contained by the length and breadth at the water-line, and mean draught of water to the under side of the rabbet of the keel; and W, the whole weight of armament in tons, including guns, carriages, powder, shot, shell, &c.

Therefore, $\frac{A}{D}$ will be equal to the number of square feet of sail to a ton of

THE QUEEN, OF 110 GUNS,
The first three decked Ship Launched in the Reign of Her Majesty Queen Victoria.

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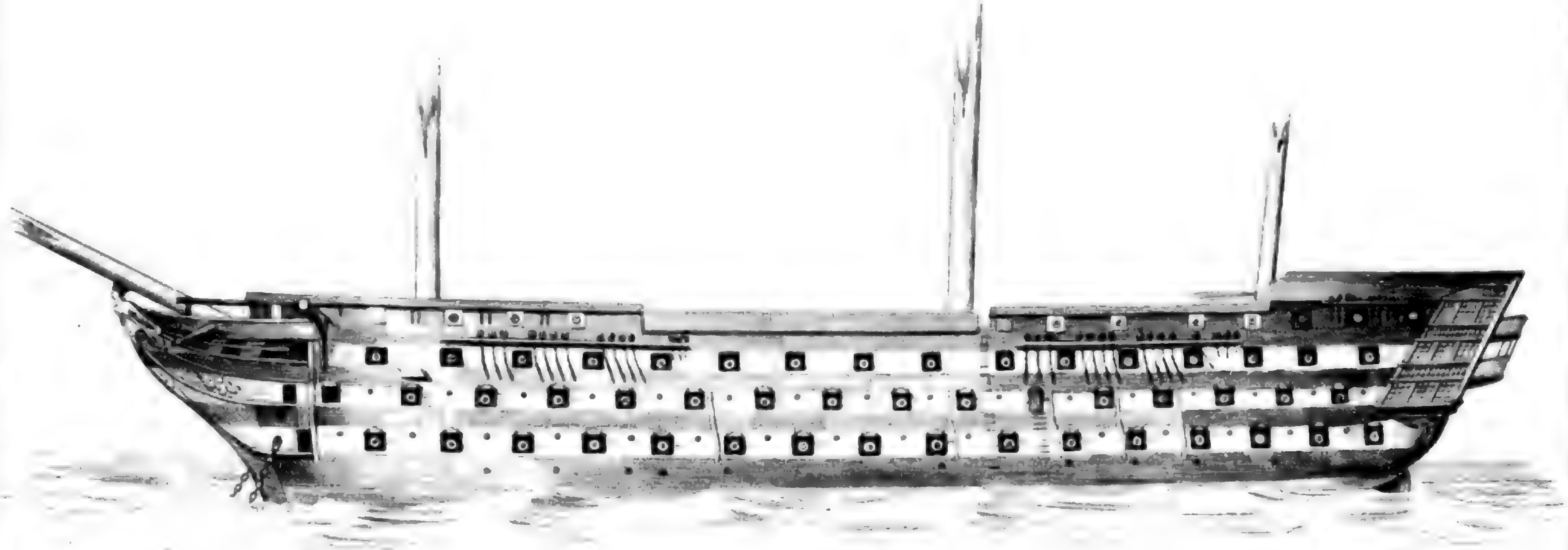

displacement; $\frac{A}{a}$, the number of square feet of sail to every square foot in the area of the midship section; and $\frac{T}{W}$, the number of tons of the parallelopiped to one ton of the armament.

	$\frac{A}{D}$	$\frac{A}{a}$	$\frac{T}{W}$
	sq. feet.	sq. feet.	tons.
Caledonia	6·15	27·71	15·67
Queen	6.26	27·91	17·10
Albion	7·19	31·79	18·10
Rodney	6.60	29·67	15·05
Vanguard	8·25	34·1	16·12
Canopus	7·74	30·02	16·44
Raleigh	9·54	37·15	21·05
Constance	9·56	36·53	22·90
Inconstant	11·20	37·01	24·11
Castor	11·83	39·0	23·10
Vestal	13·18	34·31	26·2
Eurydice	13·9	40·06	23·9

Hence it appears, on examining the proportions in the above Table, that the remarks made by sir Charles Napier, respecting the *Queen*, are fully corroborated. It may likewise be seen, upon inspecting the other proportions, how far the several ships are brought under the same conditions, as it regards their propelling power, and effectiveness as men-of-war.

Observations on the Experimental Sailing of the English and French Squadrons, under the separate commands of Admiral Sir P. Malcolm, and Admiral Ducrest.

If regard be had to the different navies of Europe, it will be seen, that England has not proceeded alone in her efforts to improve the character of her ships of war, so that, as the result of science and art, they might hold a position inferior to none of their rivals. Setting aside the more enlightened policy by which this branch of our national establishment has been governed within these few years, and the improvements which, under the countenance of that policy, have been in progress, the character of British ships has, until quite recently, been confessedly inferior in speed. And yet, with an *essential* inferiority, there were many favourable circumstances which combined frequently to give them decided advantages.

The naval establishment of France has, from its earliest development of power, ever been looked upon by the English as an object to excite their emulation. On the other hand, the French have constantly regarded the acknowledged supremacy of British power on the ocean as an object of aversion and rivalry. And the friendly correspondence which has subsisted between the two nations during the present long reign of tranquillity, has not annihilated that feeling. The more intimate is the association of the two navies, the more ample are the opportunities for each to excel, in so far as improvement may be the result of comparison and inference.

The French have recognised this advantage, and have aimed at profiting by associations of British and French ships, subsequently to the last war, and especially by the union of squadrons of English and French ships of war in the Downs, in the year 1832. The facts brought more particularly under the notice of the minister of marine, by that association, were made the subject of inquiry; and a commission was appointed in the following year to examine into the causes of the inferiority, which was acknowledged of French ships generally. Two principal objects were indicated to regulate their investigations,—*the inferiority of their ships in sailing, and the frequency of their sustaining damage.*

With an object thus limited, and yet comprehensive, claiming their attention, the commission proceeded in their inquiry, obtaining such official information as they could on the character and performances of different ships, and especially of the ships composing the French squadron, under admiral Ducrest, which had been in connection with that of the English, under the command of sir Pulteney Malcolm. And, as to the sailing of the ships, they directed their consideration to the form of the bottom, the masts and yards, the sails, the disposition of weights, including the armament, and the rigging, &c.

With respect to the form of the hull they remark, "The art of construction, like all other arts, follows the particular disposition of times and geniuses.

"It is but twenty-five years ago that the 80-gun ship, the three-decked ship, and even the frigate of M. Sané, appeared to unite, in the circumstances of that time, almost all the nautical conditions that were desirable. Since that period, however, more armament has been wanted, more water and provisions, more men, and more space on board. Hence, it has resulted, that the problem of construction, which had been much advanced by that able constructor and his predecessors, is even now, to a certain extent as it were, referred to the results of experiments; which must explain, at some time, what had been unavoidably the subject of mere conjecture. It was known, for instance, that the old 80-gun ship sailed and performed her evolutions well; that was a fact of long experience. But it cannot yet be known with equal certainty that a 90-gun ship, built after the same construction, will possess, in the same degree, the same combined advantages, with others requisite to this class of ships.

"If we are in this condition, it is probable that the English are at the same point with ourselves. It is, in effect, with them as it is with us, an epoch of transition."

Now all this confesses, that, according to the judgment of the members of this commission, there existed at that time no complete standard or model of excellence of well tried qualities, in either of the navies. Hence the necessity of proceeding cautiously, in making deductions from facts of excellence or inferiority which came under their consideration, was sufficiently apparent. The long experience of essential excellence, admitted by the English, as well as recognized by themselves, of their ships, indicated the propriety of examining first what were the circumstances which affected their sailing qualities, before allowing the expediency of any innovation which might interfere with the established system of construction. They were probably led to this conclusion by a reference to the fact, that the sailing qualities of many of their ships had materially improved after they had gone into the management of other hands: for they say, "If the floating ship is often found to accomplish her final destination better elsewhere than with us, it is probable that we must, in order to account sufficiently for this fact, have special reference to other causes than those which are deduced from the form of the body."

"It would be difficult," they say, "to establish an invariable rule of comparison, and to say, for example;—all the English ships have a greater breadth than ours; although the tendency to this modification may be sufficiently general in the British navy, especially in ships of inferior rates.

"This greater breadth is found in English construction, amongst other ships, in the 92 (54·33 feet) compared with our 90, new construction (53·47 feet); in the 80 (52·03 feet), French 86, old 80 (51·89 feet); in the 50-gun razée (48·49 feet) compared with our frigate of 60 guns (47·57); in the frigate of 46 guns (40·25 feet) compared with our frigate of 44 (40·02 feet); in the razeed frigate of 26 (38·48 feet) compared with our corvette of 32 (36·02 feet); in the corvette and brig of 18 (30·84 feet) compared with our large brigs of 20 (29·41 feet).

"This greater breadth is, on the contrary, found in the French construction of our 120 (55·31 feet), and even of our 100, after the new model (54·95 feet), compared with the English 120 (54·43 feet); In the 74—*French 82-gun ship, old 74-gun ship* (49·17 feet), *English ship of* 74 *guns* (48·16 feet); in the 52-gun frigate (45·21 feet), English 52-gun frigate (44·16 feet); in the corvettes of 24 and 32 guns (32·61 feet, and 36·02 feet) compared with the English 28-gun corvette (31·82 feet).

"If, however, it were required to generalise the expressions, to obtain an idea of the elements of the two systems, it could be said only that the English ships, taken as a whole, have the following differences:

"They are not so long as ours, with a tendency to greater breadth, which may make them appear, on the broadside to us, more powerful;

"They have a greater height of ports;

"Their mean draught of water, in comparison with that of ours, is variable;

"Their area of the section, at the line of flotation, is equal or greater;

"Their area of the midship section is less in the large ships, which would indicate that they have a less resistance of fluid to overcome;

"Their displacement is less; though in the mean it is very sensibly approaching to that of ours: their centre of gravity of the body is generally higher."

"If the ships of each kind be more exactly compared amongst themselves, the following data will be obtained:—

"*Ship of* 80 *guns*. Ours (old construction) have less length and breadth, and a greater draught of water; their area of flotation is a little greater, but the solid of immersion is greater also; lastly, the centre of gravity of the body is at a greater distance from the water-line. These various causes diminish the amount of stability dependent on the form of the body: it may then be perceived that this must be obtained by means of a greater quantity of ballast.

"The area of the midship section is greater.

"If the bodies were alike, it might be supposed, without much error, that the resistance which the fluid opposes to their movement, would be in proportion to the area of the greatest transverse section. This likeness does not exist; nevertheless the comparison of the areas of midship-section may assist in judging on which side there are the greater chances of sailing.

"*Ship of* 74 *guns*. Ours, in spite of their dimensions in length and breadth being a little greater, have a smaller area of flotation; the solid of immersion is also in truth a little less; but it must be observed that our 74s have often gone out with a draught of water of almost twenty-three feet, and that then their solid of immersion exceeded that of English ships. Their stability of form becomes, in that case, less than in the last. Our area of midship section is greater.

"*Frigate of* 44 *guns*. There is found in ours a greater length and a little less breadth, but also less draught of water; the area of flotation is greater, and that of the midship section is equal. These frigates possess excellent qualities, whenever the draught of water which was designed for them is not exceeded.

"The ships which have just been examined are those of M. Sané, which combine, in a high degree, almost all nautical qualities, when the weights are not greater than those which were estimated in the design.

"If the dimensions of the new constructions, English and French, be placed together, the following results will be obtained:—

"French ships of ninety guns, such as the *Suffren*, compared with the *London* of ninety-two.

"The *London* is longer, broader, has greater height of ports, a greater area of flotation, and displaces more water than the *Suffren*.

"The French ship has a greater draught of water, and a greater area of midship section; and the distance from the centre of gravity of the body to the line of flotation is also greater.

"Our 100-gun ship, compared with the *London*, has very nearly the same length, a little less breadth, greater draught of water and displacement, a greater height of ports, less area of flotation, and a greater area of midship section. The distance from the centre of gravity of the body is greater in the ship of 100 guns than in that of 92.

"A new 50-gun frigate (the *Vernon*), in respect of which opinions do not agree, has a little less length than our 60-gun frigate, with rather more beam than our 80; her draught of water and her solid of immersion, come near to those of our 74; the height of her ports is greater than in any other ship of the two nations; her area at the water-line is greater, and that of the midship section less, than in our 74.

"*The* 52-*gun frigate.* We shall find in ours a length about equal; much greater breadth; a greater area at the line of flotation; and, lastly, in spite of a greater solid of immersion, and of the centre of gravity of displacement being farther from the line of flotation, the metacentre is found higher. The area of the midship section is a little greater.

"Our corvettes of 24 guns, after the designs of the *Créole*, have an advantage over the English 28-gun corvettes, in a greater breadth, a less draught of water, a greater area of flotation, a less solid of immersion, less area of midship section, and in the centre of gravity of displacement approaching nearer to the load-water line. The *Créole*, according to the report of the sailing, was the best ship in the French division; but this corvette required to be trimmed exactly to her water-lines."

The variableness of the results of comparison conducted the commission to the inference, that there was some other cause of inferiority of sailing in the French ships; and this inference was confirmed by the fact, that some ships, which were originally good sailers, were subject, in a short time, to great deterioration is their qualities.

"Let us examine," they say, "the causes to which this loss of sailing of our ships is generally attributed: these are what are most commonly placed first, and to which the correspondence which we have under our eyes makes the most frequent allusion.

"1st. Their forms soon alter, as the effect of breaking, occasioned by the excess of weights, by a deficiency of support, or by an increase of body forward;

"2nd. Their water-lines alter too perceptibly, in consequence of the emersion, according as the provisions are consumed;

"3rd. Their sheathing too thin, and often badly put on at the beginning, is no longer, in the course of our ordinary practice, the object of an attention sufficiently constant, as to the inspection, the repair, and the renewing of it in proper time.

"It appears that we must in general pass condemnation on what relates to our sheathing." And with respect to the French ships in connection with the English under Admiral Malcolm, both Admiral Ducrest of the French squadron, and the respective captains of the ships, attributed their inferiority of sailing principally to the foul or defective state of the copper sheathing; and the commission concurred in that opinion.

But, independently of the state of the copper, there were other causes to which the bad sailing of some ships appeared to be justly attributed; such as the great alteration in the water-lines resulting from the consumption of provisions and stores; the bad cut and position of the sails, and the bad materials of which they were made. In reference to the first of these causes the commissioners say, "We read in the reports of the commander of the *Melpomène*, that that frigate, which in her trim at the load-water line sails probably as well as any ship, either French or foreign, loses her way, and becomes leewardly after several months' consumption of provisions.

"Here is probably something to do, and some modification to seek in the new designs, so that the ships may again enjoy all their advantages in a mean trim, and even further.

"As to the supposed alteration of the forms attributed to breaking, it must be allowed that if this cause existed in our old ships, it appears to exert only an insensible influence on those of the new construction.

"It is generally thought that the English have known how to improve the sailing of most of the French ships which the chances of war have thrown into their hands: it has often happened that their best sailers have been found to be of French origin, and this appears to be the case at the present day in respect of the *Donegal*,* one of the ships of the combined squadron.

"It appears that they have obtained this result of sailing particularly in our old frigates, by lightening their armament, reducing the length of their masts, diminishing proportionably their ballast, and increasing, in a remarkable manner, the depth of their false keel."

The system of masting the French ships, it was observed, differed materially from that which prevailed in the English navy; the masts being considerably longer, the centre of effort of the sails was of course at a higher point, whilst the tendency of the ships to a less breadth, and the mast-heads being shorter, they would have less support; but, at the same time, when the stability of the ship became reduced by the consumption of provisions and stores, it was not sufficient to bear the quantity of canvas, in connection with the great weight of masts, that was necessary to fast sailing.

We quote, however, from the report, the following observations on the comparative mastings of French and English ships:—

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* The *Donegal* was taken in the bay of Donegal, in 1798. Length on deck 182; breadth extreme 48 feet 9 inches; depth in hold 21 feet 10 inches; burthen in tons 1901.

"Our masts are generally longer than those of the English. The difference in them exists altogether in the lower masts, the topmast, and the top-gallantmast, which amongst us has a pole represented by the 33 or the 40 hundredths of the mast. The absolute length of this pole amongst the English, appears from imperfect directions drawn up in Edye, not to be sensibly different from ours.

"Our bowsprits come nearer to those of the English, and sometimes they are even shorter.

"To obtain more easily a clear idea of the absolute length of the principal masts, let it be imagined for an instant that, excepting the heads, they are placed together end to end, but only to the stops of the top-gallantmast,—the three masts which compose all the system, for example, of the mainmast; that of our 120 would exceed by nearly eighteen feet the mainmast of an English 120. This difference will be more than eight feet for the 80, and almost as much for the 74. Our corvette of 32 is almost as heavily masted as the English frigate of 46. Our 60-gun frigate has more mast than a French 74, and even almost as much as an English 80. The mast of our 44-gun frigate is 14·76 feet longer than the mast of the English frigate of 46 guns.

"If the heads be not excepted, the differences of length will become yet more sensible, those of English ships being sometimes greater than ours, even for our new masts, which have, however, given way to important alterations.

"In effect, the heads of our old masts are from 10 to 14 hundredths of their lengths, and the new from 14 to 15. Amongst the English, it appears to be from 12½ to 16½: that is to say, greater even than in our ships of the new construction, for the two principal lowermasts; equal for the mizenmast and the topmasts; a little inferior for only the mizen-top-gallantmast.

"Our lowermasts and our topmasts have generally a greater absolute diameter than those of the English. There is more variation in point of absolute diameter in the top-gallantmasts; generally, however, ours are the greater.

"Our principal yards are in general longer and larger than those of English ships.

"There are some varieties in the top-gallant-yards. The cross-jack-yard of the English, and their main-topsail-yard, are the most often perfectly equal.

"It follows from these facts, which are themselves determined from numbers of comparisons, that the masts of our ships are sensibly longer than those of the English; whilst, on the contrary, the heads may be considered shorter for our old masts, and even likewise for the mainmast and foremast in our new constructions.

"With greater entire length and less head, it is evident that our masts are more difficult to support, that is to say, less strong than those of the

English, especially from our old tendency to give less breadth than they, to our ships.

"Further, our masts being longer, larger, and consequently heavier, operate against the stability, all other things being equal; now, in many English ships, some of the conditions of stability, owing to the form of the bottom, are found to be more favourable than in our ships. Our ships will then sometimes, from this cause, be less able to carry sail.

"As to the relative strength of the two systems of pieces of mast, considered separately, it is shown that if the relation of the diameters of masts and yards to their lengths be expressed in thousandth parts, the English generally give more of these parts, that is to say, a greater relative diameter than we, to the mainmast and to the top-gallant-yards. This relation is variable for the foremast; it is less amongst them for the bowsprit and the lower-yards; almost equal in the two navies for the topmast and topsail-yards: the system of the main and fore-topmasts having always with them, and most commonly with us, the same diameter. Thus, from these data, and in proportion to their length, our mainmasts and top-gallantmasts and yards would be generally weaker than those of the English; the bowsprit and lower-yards would, on the contrary, be found stronger in our navy; there would be almost an equality of strength, in the two navies, in the topmasts and topsail-yards; and, as to the foremasts and mizenmasts, the relation would be variable.

"The general opinion of our nautical men is, that our old masts are too taunt, and that we have not always avoided this inconvenience in our ships of the new construction; they wish then, that some reductions in height may be studied and tried, the diameters of the principal masts and yards remaining as they are. Such is also the advice of the Commission." "It is known that our frigates, taken by the English, underwent corrections of this nature. It is equally an attempt of this kind, which was made at Brest, in 1821, upon the *Cleopâtre* frigate; an attempt which was decisive."

Since the lengths of masts and yards of French ships are greater than they are in English ships, it follows, that the area of their sails must be greater likewise. The results of comparisons shown in this report, prove that it is so.

In speaking of the sails of the French and English ships, the Commission say, "The difference of surface for the principal sails is always very perceptible, and it is often considerable. For example, it amounts to nearly one-sixth in our 44-gun frigate, compared with that of 46; and the sails of the English 28-gun corvette are hardly more than two-thirds of those of the French 32-gun corvette, which nearly corresponds with its force in the classification of ships, and which has as much sail, within about one-tenth, as the English 46-gun frigate.

"In the corvettes of 32 and 28 guns, the solids of immersion would be nearly as the numbers 47 and 36, whilst the areas of sail would be as

56 and 38. The height of the centre of effort above the plain of flotation is 62·33 feet in the French corvette, and 50·46 feet in the English corvette, the mean draught of water differing only a little less than two inches.

"The relative areas of sail, amongst ships of the same rate, in the two countries, are very variable. It may, however, be said, in a general way, that the English give us, that is to say, ordinarily allow us, an excess in the surface of sail almost equivalent to that of their top-gallantsails, which may represent a fifth or a sixth of the sails of each rate.

"This difference is from the lower sails between our corvette of 32 and the English corvette of 28 guns.* The area of sail of this same 28-gun corvette is less than that of our corvettes of 24 guns, by almost the double of her top-gallantsails.

"The distribution of the sails presents the following differences: The area of the topsails taken together is greater than that of the courses in many of our ships, such as the 80, the 74, the corvette of 32, and the corvette of 24. It is generally the contrary with the English; and we know of no other exceptions to this rule than their 120-gun ship and their 52-gun frigate.

"If we compare partially the sails of our ships and of the English ships with their total areas respectively, our top-gallantsails will exceed those of the English ships by 27 thousandths; our topsails will exceed the English topsails by 4 thousandths; and the lower-sails of the English, on the contrary, will exceed those of ours by 32 thousandths.

"That distribution of sails, so different from ours, combined with the shortening of the masts, contributes much to the lowering of the centre of effort, and thus, it cannot but be favourable to the stability of the English ships, without speaking of the advantages which result besides, from a very great lightness of their canvas.

"If we compare the area of the sails with that of the midship section, the advantage will appear to be, theoretically, on our side: for our ships have a greater area of sails in comparison of the midship section, than English ships. For example, these relations for our corvettes of 32 and 24 guns, compared with the English corvette of 28, are represented by the numbers 38, 42, and 30.

"We have just seen that our 32-gun corvette has one tier of sails more than the English corvette of 28 guns, and that the relations of the areas of the sails to those of the midship sections in the two ships, are expressed by the numbers 30 and 38, that is to say, that the area of sail in the French corvette contained thirty-eight times the area of the midship section, whilst the area of the midship section in the English corvette was contained only thirty times in the area of her sails. Hence it might be

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"* Difference of the area of sails between the two corvettes, 4606·88 feet."

"Area of the lower-sails of the 28-gun corvette, 4541·4 feet."

concluded, supposing that in the two ships the stability were proportioned to the system of sail, that the corvette of 32 guns would sail better than the English corvette of 28 guns. The contrary to this takes place, as we learn from the report of captain Le Roy, who, sailing with a fresh wind from the N.E., the sea heavy, with two or three reefs in her topsails, in company with two English corvettes of 26 and 28 guns, fell immediately to leeward, and remained behind. Notwithstanding this, the *Ariane* had as much sail as she could carry, and laboured much, in spite of her three reefs taken. The corvette of 26 had as many reefs as the *Ariane*: that of 28 had only two reefs.

" This fact, in connection with all that has been already said, allows us to insist on the real disadvantage that may result from our system of masts and sails, compared with the stability of many of our ships, which does not appear to be sufficiently strong in many circumstances of sailing, for the sail which ought to be carried."

After having stated the nature of the defects arising from the inferior quality of the canvas, which allows it to stretch, not only beyond the proper dimensions, but also into irregular shapes, so that the sails could not be trimmed for the wind to impinge to the best advantage upon them; and likewise from the acknowledged bad cut of the sails originally, the Commission say: " It appears desirable to study anew the cut of our sails, with a view to correct the data, from experience and from the remonstrances of seamen, under the threefold relation of the surface of the sails, their figure, and the uniformity of the outline."

The preceding observations and quotations show what, according to, perhaps, the best opinions, formed from the most ample sources of information, were the chief points and circumstances of difference and of inferiority of the French ships of war, compared with those of England. Other circumstances were recognised as means of impairing the qualities of their ships,—as the disposition of weights, being too large a proportion of them in the upper parts, the position of the masts, the condition of the rigging, &c.; but it may be sufficient to have noticed those which relate the most directly to the profession of the naval architect.

The investigation of the French commissioners was conducted on a sounder and more useful plan than has yet formed the basis of any such inquiry into the state of our own navy; it was much more analytical, whilst the elements of comparison were examined with great exactness. Sufficient analysis is essential to fair and satisfactory comparison; for generalization on such a subject as this amounts to nothing without it. And although many detached facts may be brought to bear on the subject in constructing designs, yet they cannot bear so high a value in their separate and isolated state as they would bear in forming the elements of comprehensive generalization, because the inferences deduced from them cannot be known so certainly in one case as in the other. But this certainty is necessary, and it is also attainable, since the ships of our navy are sufficiently numerous for the object, and may be brought into any analytical comparison which the claims of science demand. Why, then, has not this been done for improving the British navy, as well as for improving that of France? It is probable that a reply might be found in the fact, that the affairs of this branch of government have not been conducted on a sufficiently enlightened policy. Knowledge which could have been obtained by such means, would have been useful only to expose existing error,—not to correct it,—before the restriction of tonnage was removed; for that was a bar to the improvements which such knowledge would have sought to introduce. Since 1832, a short period only has elapsed in which the supremacy of a system of construction, resting rather upon opinions than upon science, made that class of information which might be gathered from the source now under notice, almost as useless as it was before. Under both of these preceding conditions of our naval administration, the way to general improvement was not open, although it might be indicated; this way has, however, been gradually opening since 1841; and some results which have been admitted go far enough to prove, that liberty and encouragement would surely bring the improvement which has been wanted for ages, but which has not until now been attainable. It is yet with us, as it was described in the French report to be, "an epoch of transition." With a sensible movement towards perfection, there is an obvious uncertainty as to the countenance or check which may be given to this progress. To a great extent, the navy requires to be formed on better models; and there is talent enough in the service to collect and apply information so far as to realize the improvement, which would leave room for little doubt as to the general character of ships of all classes. But will the country avail itself of this talent?

Merely practical qualifications in designing ships have been tried in our service, and found wanting. The surveyors of the navy were good practical shipbuilders, without scientific knowledge. Even their modes of calculating the contents of a ship's body, &c., were formerly rude and clumsy, in comparison of those which science has now shown to be better suited to the purposes. But yet, with all their disadvantages, a sound judgment, and solid practical knowledge of their profession, kept them from falling into serious mistakes in forming their designs for ships; and although this sort of qualification is not sufficient of itself to obtain the highest degree of excellence, yet it can never be safely dispensed with, whatever may be the theoretical talents of a constructor. If the surveyors formerly adopted the forms of foreign ships, in many cases, instead of aiming at originality of design, the choice of models generally expressed the soundness of their judgment in this respect; and they paid only a rational deference to the superior genius and accomplishments of foreign constructors, which it has always been deemed creditable to evince. If practical knowledge were sufficient to carry on improvement in ship-building, then this improvement might have advanced under the administrations whose operations they had to control; for so far as practical knowledge would realize a progress, the opportunities were presented from the beginning of the revolutionary war, except that they were bound by the restriction of limited tonnage. The ships they built were commonly what they were intended to be in their capabilities for service: they were not, it is true, excellent sailers, but they could always be depended on, with but few exceptions, for performing their evolutions; were able to keep the sea during long periods of arduous service in blockading; and they were efficient ships, in regard to the qualities which were necessary in going into and sustaining an action.

The period in which the strictly partial qualifications of the old system could be thought sufficient, in filling the responsible post of surveyor of the navy, has passed away. The nation looks now with a more piercing eye into the several departments of government; and whilst progress is exhibited almost everywhere else, it would be unreasonable to expect that the eye of cold indifference should rest with apathetic satisfaction on the proceedings of a department which has to do with the proper defensive power of the nation and its dependencies.

The following Tables show with what elaborate care the investigation of causes was conducted by the French Commission. As we are accustomed to judge of ships, as well as of most other things, rather relatively than absolutely, it is evident that inquiry into the causes of numerous effects exhibited in the performances of ships, must begin by the most general view of the subject; the widest range of analysis ought to be only the *first* step towards improvement; for it would be strange to think of reaching any important result by *one* process of that sort, since the numerous elements exhibited in the analysis require to be dealt with in detail. We observe, for instance, that, besides dissimilarity in what is essential in different ships, and in their masts, yards, and sails, the weights put on board of them differ considerably. The armament and other things put on board of a French first-rate, exceed, by nearly six hundred tons, the weight of the effects put on board of an English first-rate; and yet the draught of water is nearly alike. There is a tendency in the French ships to carry more ballast than the English ships carry. These particulars suggest questions on which the principles of stowage would have to bear. Whilst the ultimate improvements, which may be expected, must be sought in an extended course of analysis and induction, the character of the first step is exhibited in the following Tables, which were printed in the Report of the French Commission.

Principal Dimensions of Ships of various rates.

FRENCH SHIPS.

DIMENSIONS.	Ship of 120 guns.	Ship of 100 guns.	Ship of 90 guns.	Ship of 86 guns, old 80-gun ship.	Ship of 82 guns, old 74-gun ship.	Frigate of 60 guns, the *Surveillante*.	Frigate of 52 guns, the *Némésis*.	Frigate of 46 guns, M. Sané's old frigate of 44 guns.	Corvette of 32 guns, the *Ariane*.	Corvette of 24 guns, the *Créole*.	Brig of 20 guns, the *Dragon*, 1821.	Brig of 20 guns, the *Cygne*.
Length on the lower-deck, in feet	209.50	205.04	198.49	196.24	183.28	178.11	172.07	153.99	138.60	125.32	109.30	112.20
Breadth, extreme, at the midship section, in feet	55.31	54.95	53.47	51.89	49.17	47.57	45.21	40.02	36.02	32.61	29.41	30.18
Draught of water, in feet, forward	24.96	23.91	23.29	22.40	20.92	19.98	—	—	14.76	13.54	—	11.70
abaft	26.73	26.04	25.26	25.03	23.22	21.61	—	—	16.27	14.86	—	14.98
mean	25.85	24.96	24.27	23.72	22.08	20.79	20.69	18.14	15.51	14.20	11.54	13.34
Height of battery, in feet	5.31	6.56	6.56	5.87	5.83	6.56	6.56	6.39	5.90	5.90	5.31	4.78
Load displacement, in tons	5018	4462	4076	3704	2966	2582	2303	1478	1015	750	398	548
Area of plain of flotation, in sq. feet	10129.6	9639	9233	8734	7513	7190	6835	5220	4047	3232.8	—	2636.4
Area of midship section, in sq. feet	1117	1070	966	936	780	710	613	494	371	296	188.37	231.4
Distance from the centre of gravity of displacement to the section at the loadwater-line, in feet	—	8.99	8.76	9.61	—	7.18	7.18	—	5.21	4.72	—	3.97

ENGLISH SHIPS.

DIMENSIONS.	Ship of 120 guns.	Ship of 80 guns.	Ship of 74 guns.	Frigate of 52 guns.	Razée of 50 guns.	Frigate of 46 guns.	Razée Frigate of 26 guns.	Corvette of 28 guns.	Corvette of 18 guns.	Brig of 18 guns.	Brig of 10 guns.	*London*, of 92 guns.	*Vernon*, of 50 guns.	*Castor*, of 36 guns.	*Rover*, Corvette of 18 guns.	*Snake*, Brig of 16 guns.
Length on the lower-deck, in feet	204.99	196.13	175.98	171.98	173.65	150.13	145.01	113.65	112.0	100.0	89.99	205.47	175.98	158.99	112.99	100.00
Breadth, extreme, at the midship section, in feet	54.43	52.03	48.16	44.16	48.49	40.25	38.48	31.82	30.84	30.84	24.67	54.33	52.69	43.01	35.33	32.31
Draught of water, in feet, forward	24.573	21.719	20.899	19.42	20.24*	17.48	17.03†	15.16	14.66	11.32	11.42	23.23	20.73	19.09	14.01	13.48
abaft	26.57	25.00	23.78	20.40	21.49*	19.16	18.44†	15.58	15.29	14.60	12.50	24.21	21.75	20.08	14.99	14.76
mean	25.26	23.35	22.34	19.91	.. *	18.31	.. †	15.35	14.96	12.96	11.94	23.72	21.22	19.58	14.50	14.11
Height of battery, in feet	5.48	6.07	5.67	7.84	8.23	6.92	8.43	4.92	4.92	4.75	4.33	10.23	8.99	7.67	6.00	5.25
Light displacement, in metl. tons	2498	1894	1632	1046	1480	775	708	393	300	234	165	2246	1408	958	303	234
Load displacement, in ditto	4665	3625	3043	2186	2527	1471	1299	792	619	465	301	4194	2604	1853	577	442
Area of plain of flotation, in sq. ft.	10096.4	9073.99	7523.64	6781.5	7201.04	5143.75	4736.04	3143	2960	2427	1840	9870.6	7781.88	6038.2	3034.3	2400.2
Area of midship section, in ditto	1038.6	924.99	731.8	575.8	602.7	495.10	441.3	322.85	252.8	225.98	150.76	947.08	683.40	441.3	247.43	231.34
Distance from the centre of gravity of displacement to the Section at the loadwater-line, in ft.	8.563	8.33	8.04	6.63	7.18	5.81	5.90	4.89	4.16	4.03	3.77	8.30	6.99	6.16	4.33	4.23

* Plus 11.8 inches for additional keel. † Plus 5.9 inches for additional keel.

Dimensions of the principal Masts and Yards belonging to the Ships of different rates, in the French Navy.

FRENCH SHIPS.															
DESCRIPTION OF MASTS AND YARDS.	Ship of 120 guns.			Ship of 100 guns.			Ship of 90 guns.			Ship of 86 guns, old ship of 80 guns.			Ship of 82 guns, old ship of 74 guns.		
	Length.	Diamet.	Head.	Length.	Diamet.	Head.	Length.	Diamet.	Head.	Length.	Diamet.	Head.	Length.	Diamet.	Head.
	feet.	feet.	feet.	feet.	feet	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.
Main-mast	130.24	3.464	18.11	127.95	3.511	19.19	124.67	3.263	18.70	122.55	3.198	17.06	111.90	3.040	16.08
Fore-mast	119.36	3.287	17.06	120.08	3.363	18.04	116.47	3.198	17.38	111.90	3.034	15.96	103.37	2.952	14.89
Mizen-mast	88.45	2.266	11.71	88.58	2.296	12.79	118.77	2.230	13.12	81.00	2.088	10.66	77.79	1.954	10.10
Bowsprit	74.61	3.376	..	74.47	3.397	..	72.18	3.280	..	69.26	3.109	..	66.08	2.929	..
Main-topmast	77.79	1.978	9.317	74.47	1.780	10.50	72.18	1.804	10.17	74.61	1.820	9.05	69.26	1.686	8.79
Fore-topmast	71.39	1.978	8.53	66.93	1.780	9.35	64.69	1.804	9.02	68.21	1.820	8.26	64.98	1.686	7.97
Mizen-topmast	54.36	1.177	6.39	52.16	1.312	7.38	50.51	1.262	7.05	51.84	1.154	6.03	51.14	1.154	5.31
Main-topgallant-mast	54.36	1.066	19.16	55.77	1.066	18.70	54.13	1.033	18.04	51.84	0.977	17.22	50.06	0.934	17.13
Fore-topgallant-mast	47.96	0.934	17.06	50.19	0.951	16.73	49.21	0.934	16.40	45.79	0.889	15.96	43.66	0.866	13.84
Mizen-topgallant-mast	42.62	0.773	14.93	39.37	0.754	13.12	37.73	0.721	12.62	40.48	0.666	10.66	35.17	0.619	9.58
			yd. arms			yd. arms			yd. arms			yd. arms			yd. arms
Main-yard	117.22	2.332	5.31	112.86	2.427	5.08	109.57	2.362	4.92	106.55	2.220	4.78	98.02	2.088	4.26
Fore-yard	106.56	2.155	4.79	101.71	2.181	4.59	98.42	2.115	4.42	96.97	2.044	4.52	89.50	2.044	4.26
Cross-jack-yard	81.00	1.331	4.26	78.74	1.410	3.61	76.77	1.378	3.44	72.47	1.243	3.70	66.08	1.154	3.18
Main-topsail-yard	87.40	1.686	8.53	84.64	1.525	7.54	81.82	1.476	7.38	79.91	1.420	7.97	74.61	1.289	6.92
Fore-topsail-yard	81.00	1.420	7.97	76.12	1.378	6.89	73.82	1.328	6.56	72.47	1.331	7.44	66.08	1.243	6.39
Mizen-topsail-yard	60.73	0.889	4.26	59.05	1.066	3.93	57.41	1.033	3.77	55.40	0.800	3.70	51.14	0.708	3.18
Main-topgallant-yard	54.36	0.846	2.66	56.43	0.853	2.62	54.79	0.820	2.46	50.06	0.708	2.66	47.96	0.642	2.13
Fore-topgallant-yard	49.01	0.708	2.39	50.85	0.754	2.29	49.21	0.738	2.29	44.75	0.666	2.13	42.61	0.619	1.57
Mizen-topgallant-yard	42.62	0.619	2.13	39.37	0.590	1.80	38.39	0.574	1.80	38.35	0.577	1.84	36.22	0.531	1.57
Spanker-boom	69·26	1.111	1.066	67.91	1.345	..	65.62	1.312	..	63.93	0.977	0.525	58.58	1.066	1.05
Gaff	60.04	1.111	1.066	61.02	1.214	1.80	59.05	1.181	1.80	53.80	0.977	0.525	54.40	0.947	1.05

Dimensions of the principal Masts and Yards belonging to the Ships of different rates, in the French Navy.

FRENCH SHIPS.—*Continued.*

DESCRIPTION OF MASTS AND YARDS.	Frigate of 60 guns.			Frigate of 46 guns, old Frigate of 44 guns.			Corvette of 32 guns.			Brig of 20 guns.			*La Cléopâtre*, 44 gun frigate, 1833.		
	Length.	Diamet.	Head.	Length.	Diamet.	Head.	Length.	Diamet.	Head.	Length.	Diamet.	Head.	Length.	Diamet.	Head.
	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.
Main-mast	115.65	3.122	17.38	94.29	2.440	13.32	85.96	2.23	13.12	70.87	1.706	10.66	99.11	2.427	16.53
Fore-mast	106.63	2.962	15.58	84.15	2.263	12.23	79.07	2.13	11.81	67.26	1.640	10.17	87.66	2.263	14.66
Mizen-mast	81.03	2.030	12.14	67.13	1.597	9.57	60.19	1.45	9.02	..	..	..	69.00	1.597	11.44
Bowsprit	67.09	2.018	..	55.38	2.352	..	50.85	2.18	..	42.65	1.673	..	55.37	2.351	..
Main-topmast	69.39	1.732	9.84	60.73	1.466	7.97	52.49	1.31	7.38	42.65	1.066	5.90	56.29	1.420	8.00
Fore-topmast	62.33	1.558	8.69	55.38	1.466	7.18	47.24	1.31	6.36	40.68	1.066	5.74	50.45	1.420	7.18
Mizen-topmast	48.55	1.092	6.56	44.75	1.066	6.39	36.75	0.85	5.25	..	..	..	41.57	1.043	6.39
Main-topgallant-mast	52.16	0.964	17.38	47.93	0.919	17.02	39.37	0.73	13.12	42.65	0.708	17.06	44.75	0.866	17.06
Fore-topgallant-mast	46.75	0.865	15.58	42.62	0.866	14.89	35.43	0.65	11.81	42.96	0.708	16.40	40.32	0.843	15.35
Mizen-topgallant-mast	36.42	0.672	12.14	31.95	0.619	10.66	27.55	0.53	9.18	..	..	..	30.74	0.606	12.27
			yd. arms			yd. arms			yd. arms			yd. arms			yd. arms
Main-yard	98.42	2.115	4.42	85.23	1.732	3.74	76.44	1.54	4.92	61.02	1.214	2.79	86.31	1.555	3.74
Fore-yard	88.58	1.968	3.94	74.57	1.466	3.47	68.90	1.38	3.13	56.43	1.115	2.62	75.65	1.466	3.47
Cross-jack-yard	68.90	1.240	3.12	58.59	1.023	3.18	53.47	0.93	2.46	..	..	..	60.75	1.066	2.13
Main-topsail-yard	73.82	1.328	6.56	61.78	1.043	5.25	57.41	1.003	5.25	43.93	0.803	4.10	67.12	1.151	5.31
Fore-topsail-yard	66.44	1.230	5.96	54.33	0.934	4.52	51.67	0.902	4.59	43.93	0.803	4.10	58.62	1.027	4.78
Mizen-topsail-yard	51.67	0.773	3.28	47.93	0.642	3.18	40.19	0.603	2.62	..	..	..	50.10	0.708	3.74
Main-topgallant-yard	49.21	0.738	2.30	40.37	0.619	2.39	38.06	0.571	1.64	30.58	0.492	1.48	45.30	0.708	3.18
Fore-topgallant-yard	44.29	0.662	1.97	35.14	0.577	2.11	34.45	0.518	1.64	30.58	0.492	1.48	39.96	0.682	2.93
Mizen-topgallant-yard	34.45	0.514	1.64	30.90	0.554	1.61	26.73	0.426	1.15	..	..	..	35.69	0.649	1.87
Spanker-boom	59.05	1.050	1.08	57.51	0.934	1.05	45.93	0.735	1.31	55.11	0.886	1.97	57.54	0.931	..
Gaff	52.49	0.944	1.08	45.80	0.919	1.05	41.34	0.826	1.31	36.75	0.735	0.98	45.83	0.866	0.85

Dimensions of the principal Masts and Yards belonging to the Ships of different rates, in the English Navy.

DESCRIPTION OF MASTS AND YARDS.	ENGLISH SHIPS.															
	Ship of 120 guns.		Ship of 80 guns.		Ship of 74 guns.		Frigate of 50 guns.		Frigate of 46 guns.		Frigate of 28 guns.		Brig of 18 guns.		Brig of 10 guns.	
	Length.	Diamet.	Length.	Diamet.	Length.	Diamet.	Length.	Diamet.	Length.	Diamet.	Length.	Diamet.	Length.	Diamet.	Length.	Diamet.
	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.	feet.
Main-mast	119.66	3.33	118.08	3.31	108.00	3.00	108.00	3.00	90.00	2.33	71.00	1.70	68.25	1.81	54.5	1.47
Fore-mast	110.33	3.06	108.00	3.00	98.50	2.60	98.50	2.60	82.50	2.08	64.50	1.58	58.75	1.66	46.5	1.33
Mizen-mast	81.66	2.04	81.66	2.06	73.09	1.80	79.33	2.00	65.00	1.58	54.00	1.35	..	..	..	..
Bowsprit	63.00	3.07	71.09	3.00	66.00	2.92	66.00	2.92	54.50	2.20	44.59	1.75	43.33	1.66	36.00	1.41
Main-topmast	68.08	1.71	69.00	1.72	64.08	1.60	64.08	1.60	54.00	1.34	43.16	1.06	38.09	1.02	31.0	0.83
Fore-topmast	68.08	1.71	62.16	1.72	57.66	1.60	57.66	1.60	47.08	1.34	38.16	1.06	36.50	1.02	31.0	0.83
Mizen-topmast	49.41	1.14	50.33	1.16	47.66	1.08	47.66	1.08	41.00	0.99	32.41	0.75	..	..	..	..
Main-topgallant-mast	34.41	0.97	34.50	0.97	33.00	0.91	33.00	0.91	27.00	0.75	21.58	0.59	25.08	0.59	19.5	0.50
Fore-topgallant-mast	31.00	0.86	30.00	0.83	28.08	0.80	28.08	0.80	23.41	0.64	19.00	0.56	25.08	0.59	19.5	0.50
Mizen-topgallant-mast	24.66	0.71	24.66	0.70	24.00	0.66	24.00	0.66	20.50	0.57	16.33	0.45	..	..	..	..
Main-yard	104.33	2.05	103.25	2.05	96.06	1.89	96.66	1.89	81.75	1.57	63.00	1.20	54.58	0.94	48.09	0.91
Fore-yard	91.08	1.79	89.75	1.79	84.33	1.63	84.33	1.63	71.41	1.36	55.00	1.05	54.50	0.94	48.00	0.91
Cross-jack-yard	74.50	1.29	74.25	1.33	70.50	1.21	70.50	1.21	59.00	1.18	46.50	0.81	..	..	..	..
Main-topsail-yard	73.66	1.29	74.25	1.33	70.50	1.21	70.50	1.21	59.00	1.18	46.50	0.81	42.00	0.70	37.5	0.66
Fore-topsail-yard	64.50	1.14	64.66	1.15	61.50	1.06	61.50	1.06	53.33	0.95	41.00	0.70	42.00	0.70	37.5	0.66
Mizen-topsail-yard	49.00	0.84	49.00	0.84	46.08	0.80	46.08	0.80	40.66	0.68	31.00	0.48	..	..	..	..
Main-topgallant-yard	48.75	0.83	46.00	0.78	45.83	0.77	45.83	0.77	37.50	0.60	28.33	0.50	27.50	0.50	26.00	0.50
Fore-topgallant-yard	42.66	0.71	38.43	0.66	40.00	0.70	40.00	0.70	32.91	0.56	25.00	0.45	27.50	0.50	26.00	0.50
Mizen-topgallant-yard	36.25	0.54	34.00	0.58	31.75	0.51	31.75	0.51	28.00	0.45	21.33	0.37	..	..	..	..
Spanker-boom	69.58	1.14	70.01	1.15	68.25	1.06	68.25	1.06	55.75	0.95	43.91	0.70	58.00	1.12	50.66	0.91
Gaff	51.50	1.05	52.00	1.00	50.91	0.96	50.91	0.96	39.00	0.78	32.50	0.64	34.00	0.78	30.33	0.62

FRENCH SHIPS.											
RATES.	Area of the			Total Area.	Relation			Relation of the Areas			
	Lower sails: Mainsail Foresail, Spanker.	Top-sails.	Top-gallant-sails.		of the lower sails	of the top-sails	of top-gallant sails	of the lower sails	of the top-sails	of top-gallant sails	Total.
					to the sum total.			to the area of midship section.			
	sq. ft.	sq. ft.	sq. ft.	sq. ft.							
Ship of 120 guns ...	12970. 9	15388	5703	34062	0·381	0·451	0·168	11·6	13·7	5·1	30·4
Ship of 90 guns	12593	13067	5574	31237	0·403	0·418	0·179	12·9	13·4	5·7	32·0
Ship of 86 guns, old 80-gun ship	11303	12486	5091	28879	0·392	0·432	0·176	12·1	13·3	5·4	30·8
Ship of 82, old 74 ..	10075	11141	4887	26103	0·386	0·427	0·187	13·0	14·2	6·2	33·4
Frigate of 60 guns ..	11894	10699	4402	26996	0·441	0·396	0·163	16·7	15·1	6·2	38·0
Frigate of 52 guns ..	10387. 4	9673	3821	23886	0·435	0·405	0·160	16·9	15·7	6·2	38·8
Frigate of 46, old 44	8202. 3	7643	3078	18923	0·433	0·404	0·163	16·5	15·4	6·2	38·1
Corvette of 32	5328	6060	2983	14370	0·371	0·422	0·207	14·3	16·2	8·0	38·5
Corvette of 24.......	5166	5208	2142	12433	0·416	0·418	0·166	17·5	17·6	6·9	42·0
	Foresail, Spanker.				Foresail, Spanker.			Foresail, Spanker.			
Brig of 20 guns	3337	3359	1808	8503	0·392	0·395	0·213	14·4	14·5	7·8	36·7
ENGLISH SHIPS.											
RATES.	Mainsail Foresail, Spanker.				Mainsail Foresail, Spanker			Mainsail Foresail, Spanker			
Ship of 120 guns ...	9968	10613	3929	24510	0·406	0·433	0·161	9·6	10·2	3·7	23·5
Ship of 80 guns	11281	10624	3692	25597	0·441	0·415	0·144	12·2	11·4	4·0	27·6
Ship of 74 guns	9655	9322	3348	22325	0·423	0·417	0·150	13·2	13·7	4·6	31·5
Razée of 50 guns ..	11001	9322	3348	23670	0·464	0·394	0·142	18·2	15·4	5·5	39·1
Frigate of 52 guns ..	9203	9322	3348	21873	0·421	0·426	0·153	16·0	16·2	5·8	38·0
Frigate of 46 guns ..	7320	6394	2260	15974	0·458	0·401	0·141	14·7	12·9	4·5	32·1
Razeed frigate of 26	7061	6308	2260	15629	0·452	0·403	0·145	16·0	14·2	5·1	35·3
Corvette of 28 guns .	4543	3778	1442	9763	0·465	0·387	0·148	14·0	11·7	4·5	30·2
Corvette of 18 guns .	4822	3778	1442	10043	0·480	0·376	0·144	19·1	14·9	5·7	39·7
	Foresail, Spanker.				Foresail, Spanker			Foresail, Spanker			
Brig of 18 guns	2928	2626	1432	6986	0·419	0·376	0·205	13·0	11·6	6·3	30·9
Brig of 10	2110	1937	958	4995	0·423	0·385	0·192	14·0	12·8	6·3	33·1

Relation of the Diameters of Masts to their Length.

MASTS.	FRENCH SHIPS.				ENGLISH SHIPS.		
	Ships and Frigates constructed by M Sané.	Ships and Frigates of the new construction.	Corvettes.	Brigs.	Ships and Frigates.	Corvettes.	Brigs.
Main-mast	0·026 to 0·027	0·027 to 0·0275	0·026	0·024	0·026 to 0·029	0·024 to 0·0265	0·026 to 0·0285
Fore-mast	0·027 0·028	0.027 0·028	0·027	0·025	0·025 0·0285	0·024 0·0265	0·0265 0·0285
Mizen-mast......	0·024 0·026	0·0245 0·026	0·024	..	0·024 0·026	0·024 0·025	.. ..
Bowsprit	0·043 0·045	0·044 0·0455	0·043	0·039	0·040 0·0243	0·040	0·0385 0·0445
Main-top-mast ..	0·024 0·0255	0·025	0·025	0·025	0·0245 0·026	0·0245 0·027	0·0255 0·027
Fore-top-mast .	same diameter as the main topmast.	same diameter as main-topmast, or 0·025 of the length.	Same diameter as the main-topmast		Same diameter as the main-topmast, except in the masts of the *Rover*.		
Mizen-top-mast..	0.0215 0·024	0·0225 0·025	0·023	..	0·023 0·024	0·023 0·025	.. ..

Relation of the Diameters of Yards to their length.

Main-yard	0·020 to 0·021	0·0205 to 0·0215	0·020	0·020	0·019 to 0·020	0·019 to 0·022	0·0175 to 0·019
Fore-yard	0·020 0·023	0·021 0·022	0·020	0·020	0·016 0·0215	0·019 0·0235	diam as main yd
Cross-jack-yard ..	0·0165 0·0175	0·018	0·017	..	0·017 0·018	0·0175 0·0185	..
Main-topsail-yard	0·017 0·0195	0·018	0·0175	0·0175	0·017 0·018	0·0175	0·017 0·018
Fore-topsail-yd.	0·017 0·019	0·018 0·0185	0·0175	same diam. as main-topsail-yd.	0·017 0·018	0·017	same diameter as the main-topsail-yard.
Mizen-topsail yard	0·0135 0·0145	0·015 0·018	0·015	..	0·0165 0·0175	0·0145	..
Main-topgal.-yard	0·0135 0·0155	0·015	0·015	0·016	0·016 0·017	0·017 0·0175	0·018 0·0195
Fore-topgal.-yd.	0·0145 0·0165	0·015	0·015	same diam as main topgal.-yd	0·0165 0·018	0·0175 0·0185	same diam. as the main-topgal. yard
Mizen-topgal.-yd.	0·0145 0·017	0·015 0·016	0·016	..	0·015 0·018	0·0155 0·018	..

Relation of the Mast-heads to the length of the Masts.

	Ships constructed by M. Sané.	Ships of the new construction.	English Ships.
Main-mast............	0·14	0·15	0·165
Fore-mast	0·145	0·15	0·165
Mizen-mast	0·13 to 0·14	0·15	0·14
Main-top-mast........	0·12 0·13	0·14	0·14
Fore-top-mast	0·12 0·13	0·14	0·14
Mizen-top-mast	0·105 0·14	0·14	0·125

Weights of the different objects put on board of Ships of various rates, in their equipment.

OBJECTS.	FRENCH SHIPS.														ENGLISH SHIPS.						
	Ship of 120 guns.		Ship of 90 guns.		Ship of 86 guns.		Frigate of 60 guns.		Frigate of 46 guns.		Corvette of 32 guns.		Brig of 20 guns.		Ship of 120 guns.	Ship of 80 guns.	Ship of 74 guns.	Razée of 50 guns.	Frigate of 46 guns.	Corvette of 28 guns.	Brig of 18 guns.
	No. of days' provisions and water.	Weight in English tons	No. of days' provisions and water.	Weight in English tons	No. of days' provisions and water.	Weight in English tons	No. of days' provisions and water.	Weight in English tons	No. of days' provisions and water.	Weight in English tons	No. of days' provisions and water.	Weight in English tons	No. of days' provisions and water.	Weight in English tons	Weight in tons.	Weight in tons.	Weight in tons.	Weight in tons.	Weight in tons.	Weight in tons.	Weight in tons.
Ordnance and stores		614.0		475.4		481.6		293.1		172.7		107.0		57.9	528.5	375.3	301.2	268.6	150.3	73.7	52.4
Masts, sails, rigging and stores		423.7		359.6		275.9		234.5		137.9		115.3		54.1	321.4	308.8	260.4	264.3	165.4	91.7	60.9
Boats and their gear		13.8		12.8		11.8		9.8		7.9		6.9		2.9	10.0	9.7	9.6	10.2	8.7	3.7	2.5
Crew, and their effects		107.3		79.9		79.9		50.5		32.2		22.5		11.1	102.3	78.0	65.0	48.1	27.1	18.1	14.3
Provisions, beverages, and *tare*	180	465.1	240	453.2	180	340.9	300	359.3	180	142.8	180	98.7	180	50.0	296.4	241.9	215.1	134.2	69.2	31.7	23.7
Fuel	180	92.9	240	110.7	180	83.0	300	93.0	180	37.1	180	27.9	180	18.6	100.1	78.0	52.0	45.0	32.0	14.9	8.4
Water, tanks, and casks	120	380.8	120	279.3	120	279.3	120	178.3	120	113.3	120	80.0	120	39.4	410.6	385.2	260.6	175.1	110.0	55.3	32.0
Ballast		640.4		374.4		335.0		187.2		147.8		98.5		69.0	373.1	247.2	196.2	100.1	107.5	{55.2 to 80.8}	47.0
Total		2738.0		2145.3		1887.4		1405.7		791.7		556.8		303.0	2142.4	1724.1	1360.1	1045.6	670.2	370.0	241.2

The weight of water in the French ships has been calculated at a consumption of 2.46 litres (4.269 pints) by each man per day. If this quantity were increased to 3 litres (5.283 pints), which has been already done in many ships, it would be necessary to increase this weight about one-fifth.

Summary of the Weights of Ordnance put on board of the undermentioned Ships.

FRENCH SHIPS.							
ORDNANCE, &c.	Ship of 120 guns.	Ship of 90 guns.	Ship of 86 guns.	Frigate of 60 guns.	Frigate of 46 guns.	Corvette of 32 guns.	Brig of 20 guns.
	tons.	tons.	tons.	tons.	tons.	tons.	tons.
Guns, carriages, & small arms	357.0	270.3	277.4	164.2	97.2	52.5	28.6
Powder and cases	25.0	35.0	38.4	21.6	13.4	7.81	4.6
Projectiles, wadding, &c.	200.7	144.0	141.5	92.6	52.5	41.1	21.8
Spare stores, &c.	31.3	26.1	24.3	14.7	9.6	5.6	2.9
Total	614.0	475.4	481.6	293.1	172.7	107.0	57.9

ENGLISH SHIPS.							
ORDNANCE, &c.	Ship of 120 guns.	Ship of 80 guns.	Ship of 74 guns.	Razée of 50 guns.	Frigate of 46 guns.	Corvette of 28 guns.	Brig of 18 guns.
	tons.	tons.	tons.	tons.	tons.	tons.	tons.
Guns, carronades, &c.	329.9	224.2	178.3	150.9	80.3	31.1	21.8
Powder and cases	33.2	25.0	20.8	18.6	11.9	4.9	2.7
Projectiles, wadding, &c.	125.7	98.6	79.8	80.6	45.5	30.1	22.1
Spare stores, &c.	39.7	27.5	22.3	18.5	12.6	7.6	5.8
Total	528.5	375.3	301.2	268.6	150.3	73.7	52.4

Weight of Ordnance on Board of the French National Ships.

DESCRIPTION OF ORDNANCE. (*The Year 1833.*)			POWER AND RATE OF THE SHIPS.																																		
			Ship of 120 guns, Old Armament.					Ship of 90 guns, Third Rate.					Ship of 80 guns, Old 80-gun Ship.					Frigate of 60 guns, First Class.					Frigate of 46 guns, Old Armament.					Corvette, with quarter-deck and forecastle, of 32 guns.					Large Brig of 20 guns.				
			Quantities.	Weight.				Quantities.	Weight.				Quantities.	Weight.				Quantities.	Weight.				Quantities.	Weight.				Quantities.	Weight.				Quantities.	Weight.			
				tns.	cw.	qr.	lb.		tns.	cw.	qr.	lb.		tns.	cw.	qr.	lb.		tns.	cw.	qr.	lb.		tns.	cw.	qr.	lb.		tns.	cw.	qr.	lb.		tns.	cw.	qr.	lb.
Guns and their Furniture	Cannons of	36	32	136	15	1	13	..		..			30	128	4	1	25	..		..			..		..			..		..			..		..		
		30 long	..		..			30	113	7	2	16	..		..			30	113	7	2	16	..		..			..		..			..		..		
		30 short	..		..			32	106	13	3	5	..		..			..		..			..		..			..		..			..		..		
		24	34	105	12	3	22	..		..			30	90	5	1	16	..		..			..		..			..		..			..		..		
		18 long	4	10	2	2	24	4	10	2	2	24	4	10	2	2	24	2	5	1	1	12	28	70	19	0	0	..		..			..		..		
		18 short	..		..			..		..			..		..			..		..			2	4	8	3	0	4	8	17	2	0	2	4	8	3	0
	Carronades of	36	50	87	18	0	24	..		..			20	35	3	1	5	..		..			..		..			..		..			..		..		
		30	..		..			24	36	7	0	4	..		..			28	42	8	0	26	..		..			28	42	8	0	26	..		..		
		24	1	1	5	1	9	..		..			1	1	5	1	9	..		..			16	20	5	0	21	..		..			18	22	15	3	23
		18	..		..			1	0	16	2	14	..		..			1	0	16	2	14	..		..			..		..			..		..		
		12	1	0	11	1	0	1	0	11	1	0	1	0	11	1	0	1	0	11	1	0	1	0	11	1	0	1	0	11	1	0	1	0	11	1	0
	Swivel guns		4	0	7	3	9	4	0	7	3	9	4	0	7	3	9	4	0	7	3	9	4	0	7	3	9	4	0	7	3	9	4	0	7	3	9
	Blunderbusses		8	0	6	0	11	8	0	6	0	11	8	0	6	0	11	8	0	6	0	11	8	0	6	0	11	8	0	6	0	11	8	0	6	0	11
Copper Cases for Cartridges	No. 1		54	0	17	0	0	..		..			50	0	15	3	0	..		..			..		..			..		..			..		..		
	No. 2		237	3	5	1	12	..		..			223	3	1	2	0	..		..			..		..			..		..			..		..		
	No. 3		..		..			103	1	12	1	23	..		..			50	0	15	3	0	..		..			..		..			..		..		
	No. 4		..		..			66	0	19	2	0	..		..			25	0	7	1	15	..		..			..		..			..		..		
	No. 4, second		..		..			230	4	6	0	8	..		..			119	2	4	2	4	..		..			..		..			..		..		
	No. 5		265	3	17	0	0	..		..			138	2	0	0	10	..		..			..		..			..		..			..		..		
	No. 6		312	4	2	3	23	..		..			298	3	19	0	27	..		..			..		..			..		..			..		..		
	No. 7		..		..			..		..			..		..			..		..			66	1	0	3	11	..		..			..		..		
	No. 8		40	0	11	2	13	105	1	10	2	0	40	0	11	2	13	102	1	9	2	14	144	2	1	3	8	111	1	12	1	0	70	0	16	0	16
	No. 9		..		..			..		..			5	0	0	3	15	..		..			3	0	0	2	3	..		..			1	0	0	0	20
Gunpowder	for battle		..	59	18	3	13	..	24	18	0	16	..	24	8	3	14	..	13	19	0	24	..	8	2	2	24	..	4	2	3	0	..	2	5	1	19
	inferior, for salutes, &c.		..	1	3	2	15	..	1	3	2	15	..	1	3	2	15	..	1	3	2	15	..	0	17	2	25	..	0	10	3	9	..	0	9	3	10
	fine, for priming		..	0	1	0	6	..	0	0	3	8	..	0	0	3	6	..	0	0	2	6	..	0	0	1	24	..	0	0	1	4	..	0	0	0	22
Matches, for action			..	0	10	3	7	..	0	10	3	7	..	0	7	3	5	..	0	5	2	0	..	0	4	0	19	..	0	2	3	18	..	0	1	3	11
	Carried forward			417	8	0	5		303	14	3	20		302	16	2	8		183	5	0	26		109	6	1	15		58	19	3	21		32	3	2	1

Weight of Ordnance on board of the French National Ships.—(Continued.)

DESCRIPTION OF ORDNANCE. (*The Year* 1833.)	POWER AND RATE OF THE SHIPS. Ship of 120 guns. Old Armament. Quantities	Ship of 120 guns. Old Armament. Weight. tns. cw. qr. lb.	Ship of 90 guns. Third Rate. Quantities	Ship of 90 guns. Third Rate. Weight. tns. cw. qr. lb.	Ship of 86 guns, Old 80-gun Ship. Quantities	Ship of 86 guns, Old 80-gun Ship. Weight. tns. cw. qr. lb.	Frigate of 60 guns, First Class. Quantities	Frigate of 60 guns, First Class. Weight. tns. cw. qr. lb.	Frigate of 46 guns. Old Armament. Quantities	Frigate of 46 guns. Old Armament. Weight. tns. cw. qr. lb.	Corvette with quarter-deck and forecastle, of 32 guns. Quantities	Corvette with quarter-deck and forecastle, of 32 guns. Weight. tns. cw. qr. lb.	Large Brig of 20 guns. Quantities	Large Brig of 20 guns. Weight. tns. cw. qr. lb.
Brought forward		417 8 0 5		303 14 3 20		302 16 2 8		183 5 0 26		109 6 1 15		58 19 3 21		32 3 2 1
Shot. Round shot		127 11 2 4		100 17 3 21		100 3 1 17		60 2 2 0		35 10 1 2		27 7 2 8		14 5 0 23
Shot. Bar-shot, or double-headed shot		5 0 1 23		4 15 0 15		4 14 2 5		2 6 0 10		1 6 2 10		0 3 2 5		0 1 3 2
Shot. Langrage for cannon, swivels, & blunderbs.		10 11 2 4		12 7 0 0		11 16 1 12		7 2 1 17		4 3 3 17		0 16 0 16		0 9 0 6
Shot. Ditto in large and small balls for carronades		29 0 2 9		12 3 0 17		12 3 1 0		14 0 3 25		6 9 1 6		8 18 3 25		4 14 3 0
Wadding for cannon, carronades, swivels, and blunderbusses		18 13 3 12		13 13 3 1		13 9 0 24		8 18 2 19		4 19 0 5		4 0 0 0		2 1 2 12
Blank cartridges for ditto ditto		0 15 0 14		0 12 1 23		0 14 0 6		0 7 0 1		0 3 3 1		0 2 0 13		0 1 0 4
Grenades, signal-rockets, &c., and copper cases to contain them		0 16 3 4		0 16 2 2		0 15 1 2		0 15 2 18		0 13 2 9		0 10 0 25		0 9 0 19
Muskets and musketoons, including the cases of the bayonets		1 5 1 20		1 0 0 2		0 19 2 11		0 11 3 7		0 9 2 8		0 8 0 9		0 5 0 9
Pistols		0 5 3 9		0 4 2 9		0 4 1 20		0 2 2 7		0 2 0 11		0 1 3 13		0 1 0 7
Battle-axes, boarding-pikes, cutlasses for the marines, and for the seamen in boarding		0 13 2 20		0 10 2 8		0 10 1 12		0 6 1 26		0 4 3 0		0 3 3 14		0 2 3 0
Cartridges. Ball for muskets, musketoons, & pistols		2 0 3 0		1 11 1 14		1 11 1 16		0 19 0 21		0 15 1 9		0 12 3 21		0 8 0 16
Cartridges. Powder for muskets and musketoons		0 0 2 16		0 0 2 5		0 0 2 1		0 0 1 5		0 0 0 27		0 0 0 23		0 0 0 14
Flints for muskets, musketoons, and pistols		0 1 0 18		0 0 3 21		0 0 3 22		0 0 2 4		0 0 1 25		0 0 1 13		0 0 0 26
Lead and rags for the gun-flints		0 0 1 16		0 0 1 6		0 0 1 5		0 0 0 22		0 0 0 17		0 0 0 13		0 0 0 8½
Tools and utensils for the arms, such as worms of cannon, priming-irons, screwdrivers, &c. &c.		0 0 0 12		0 0 0 10		0 0 0 9		0 0 0 5½		0 0 0 4¾		0 0 0 4		0 0 0 2¼
Soldiers' accoutrements		0 9 3 5		0 7 3 16		0 5 2 8		0 4 2 3		0 3 2 20		0 3 0 14		0 1 3 26
Drum-cases, with cloth stick-cases, &c., horns, fifes, with cases and slings		0 0 2 19		0 0 2 19		0 0 2 19		0 0 2 19		0 0 2 0		0 0 1 9		0 0 1 9
Total		614 16 1 14		452 17 3 13		450 6 2 1		279 4 3 11		164 9 2 18		102 9 1 22		55 5 3 17
$\frac{1}{20}$ more for spare stores		30 14 3 7		22 12 3 16		22 10 1 8		13 19 0 27		8 4 1 26		5 2 1 25		2 15 1 5
General total		645 11 0 21		475 10 3 1		472 16 3 9		293 4 0 10		172 14 0 16		107 11 3 19		58 1 0 22

Length and Weight of the Pieces of Ordnance used in the Ships of the two Nations.

FRENCH SHIPS.		Length from the base-ring and ogee to the *tranche*.	Weight from the Tables.		
	Denomination of the Pieces.	feet.	cwt.	qrs.	lbs.
Long Guns.	36 pounder long	9.593	69	0	19
	36 ,, short	8.835	59	2	18
	30 ,, long	9.281	59	3	3
	30 ,, short	8.064	51	1	2
	24 ,, long	9.088	49	1	12
	24 ,, short	8.490	43	0	9
	18 ,, long	8.526	40	2	15
	18 ,, short	8.038	33	2	3
	12 ,,	7.991	28	3	16
Carronades.	36 pounder rectifié	5.951	21	2	24
	30 ,,	5.862	21	2	20
	24 ,, rectifié	5.156	14	3	13
	18 ,,	4.710	11	1	9
	12 ,,	4.087	7	2	0

ENGLISH SHIPS.	Denomination of Pieces, New Establishment.					
	In English.	In French.	Length.	Weight.		
		liv.	feet.	cwt.	qrs.	lbs.
Cannons of	10 inches		9.33	84	0	0
	68 lbs.	62.98	8.00	60	0	0
			6.66	50	0	0
	32	29.64	9.58	63	0	0
			9.497	56	0	0
			8.00	48	0	0
			6.42	32	0	0
			6.00 5.33	25	0	0
	24	22.06	9.497	50	0	0
			9.00	47	2	0
			7.496	40	0	0
	18	16.67	9.00	42	2	0
			8.00	37	2	0
	12	11.11	9.00	34	0	0
			7.496	29	2	0
	9	8.33	7.496	26	0	0
	6	5.52	6.00	17	0	0
Carronades.	42	38.90	4.33	22	0	0
	32	29.64	4.00	17	0	0
	24	22.06	3.3	10	0	0
	12	11.11	2.667	6	0	0

ON STEAM NAVIGATION.

The origin and progress of steam navigation are interesting, on account of the great advantages which society obtains from the use of the steam-engine in propelling ships and vessels. These advantages are so numerous and important, that the employment of steam power in navigation may be justly ranked amongst the most valuable applications of science, by which the present age is distinguished. The importance of steam navigation has increased rapidly within a brief space of time; and still new benefits are being obtained, as the rewards of the zeal and enterprise which increase its application. It has been used chiefly for three objects,—to facilitate and increase social intercourse, to promote commerce, and to aid in the operations of war. To the first and second of these, general experience is the witness of its advantage; but the advantages of the third have been scarcely tried; hence, although they may be, as they certainly are, highly calculated upon, they are not known as facts. Humanity may entertain the hope, that should the awful horrors and animosities of war, which are now slumbering, be revived by fresh national convulsions, the contemplated use of steam navigation may diminish those horrors, and shorten the reign of those animosities. It may be used as a means of inflicting severe calamities, if it be employed with vigour; but perhaps it may also hasten on the crisis which is always contemplated in the wars of civilized countries,—the restoration of peace, and the recognition and establishment of the rights of nations. Still it is to be hoped that the relations of the different parts of the world will always be such, as to give an incomparably higher degree of importance to that employment of it which relates most directly to the welfare of mankind, by an enlarged development of their sympathies, rather than to that which tends to sever the bonds of brotherhood.

If we reason from the past and present to the future, we may find *grounds* to hope that this will be the case; for its employment had been established, and the use of it had become a habit, for those objects which aim at improving the condition of man, by a more general diffusion of comforts in commerce, and by raising the tone of civilization by an extension of friendly intercourse, before any efforts were made towards forming a *steam navy*, either in England or elsewhere. The force of habit here may advance the best objects; and establish on an immoveable basis of pre-eminence, the use of steam navigation to improve, and refine, and elevate the social condition of our species, in opposition to that use of it which, in itself, tends directly to devastate and destroy. Besides, the use of steam navigation, in its benign aspect, has already proved its great advantages, and has received and encouraged so much zealous support and enterprise, as may be reasonably looked upon as a pledge of its future eminence and achievements. This is worthy of an enlightened age; and it is a good omen, that whilst philanthropists are employing their efforts and influence to diminish the severity of those calamities to which humanity is subject,—there is another grand agency at work, capable of producing such positive advantages, wherever man develops his social character. And it may be hoped, that the more enlightened policy of the present age, in establishing an intercourse with people yet uncivilized, will contribute its advantage in connection with whatever exertions may be made to extend the benefits of commerce, and improve man's social condition.

It is somewhat remarkable that distinct efforts, in different countries, and at distant periods of time, should be made, to realize mechanical power for navigation by means of steam; and that each of these efforts should fall into oblivion, leaving the distinguished authors of steam navigation to the necessity of thinking and contriving, as if nobody had conceived ideas on the same subject before: yet such appears to have been the case.

The earliest claim to the discovery is made by Spain, on behalf of Blasco de Garay, a sea captain. The account of it was in the original records which had been preserved in the royal archives of Simancas, among the state-papers of the city of Catalonia, and those of the naval secretary of war, in the year 1543, and was extracted on the 27th August, 1825, by the keeper, who signed his name "Tomas Gonzalez." It is as follows:

"Blasco de Garay, a sea captain, proposed to the emperor and king Charles V., in the year 1543, an invention for propelling vessels and large ships, even during calms, without the aid of oars or sails.

" Notwithstanding the obstacles and opposition which this proposal had to encounter, the emperor agreed that it should be tried, which was accordingly done in the harbour of Barcelona, on the 17th June, of the above-named year 1543.

" Garay would never reveal his invention; but it was seen at the time of the trial that it consisted in a large cauldron of boiling water, and in some wheels of complicated movement on each side of the vessel.

" The experiment was made on a vessel of 200 tons, which had come from Calibre to discharge wheat at Barcelona, called the *Trinidad*, Pedro de Scarza, master.

" By commission of Charles V., and of his son, prince Philip II., the business was entrusted to Don Enrique de Toledo, the governor Don Pedro Cardona, the treasurer Ravago, the Vice-chancellor, the Provedore of Catalonia, Don Francisco Gallo, and many other persons of rank, both Castillians and Catalonians, and among them many naval men who witnessed the operation, some on board the vessel, and others from the shore.

" In the reports that were made to the emperor and the prince, all generally applauded the invention, especially the promptitude with which the ship was turned. The treasurer, Ravago, who was unfriendly to the project, stated that she went two leagues in three hours; that it was very complicated and costly; and, that there was great danger of the boiler frequently bursting. The other commissioners reported that the vessel went twice as fast as a galley propelled in the usual way, and that she went at least a league per hour.

" When the experiment was concluded, Garay removed all the machinery, which he had fitted in the vessel, and the timber having been deposited in the arsenal of Barcelona, he retained all the rest in his own power.

" Notwithstanding the difficulties and contradictions started by Ravago, the invention was approved; and, had not the emperor been diverted by the expedition in which he was then engaged, he would doubtless have prosecuted and patronized it. As it was, he promoted the author to a higher rank, gave him a gratuity of 200,000 *maravédis*,* ordered the expenses to be all paid out of the general treasury, and bestowed other favours on him.

" This is stated in the original records which are preserved in the royal archives of Simancas, among the state-papers of the city of Catalonia, and those of the naval secretary of war, in the above-named year, 1543.

" Simancas, 27th August, 1825.

" TOMAS GONZALEZ."

In the resuscitation of this art, there appears something more worthy of the author of a great invention, than is to be seen in the conduct of the

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* About £61 13*s.* 4*d.* sterling.

Spaniard. Jonathan Hulls, who gave birth to the idea of steam navigation in England, took out a patent in 1736, to secure the advantages of his discovery; and, in a small book which he published, in 1737, on the subject of his invention, he gave both a description and a drawing of the manner in which he proposed to propel vessels. The paddle-wheel in this design was placed in a frame at the stern of the boat; and its connection with the machinery was formed by means of straps. The author of this design seems to have intended his boats to be employed for the purpose of towing ships in rivers and harbours, when the wind should be unfavourable to their sailing: a work of subordinate rank amongst the important services in which steam vessels are now engaged.

The following is an extract from that book, wherein the author explains the adaptation and construction of his machine. "In some convenient part of the tow boat, there is placed a vessel, about two-thirds full of water, with the top close shut. This vessel being kept boiling, rarifies the water into a steam. This steam being conveyed through a large pipe into a cylindrical vessel, and there condensed, makes a vacuum, which causes the weight of the atmosphere to press on this vessel, and so presses down a piston that is fitted into a cylindrical vessel, in the same manner as in Mr. *Newcomen's* engine, with which he raises the water by fire.

"In Plate 33, fig. 1, P is the pipe coming from the furnace to the cylinder. Q, the cylinder wherein the steam is condensed. R, the valve that stops the steam from coming into the cylinder, whilst the steam within the same is condensed. S, the pipe to convey the condensing water into the cylinder. T, a cock to let in the condensing water, when the cylinder is full of steam, and the valve *p* is shut. U, a rope fixed to the piston that slides up and down the cylinder. *Note.*—This rope, U, is the same rope that goes round the wheel D in the machine, fig. 2.

"The Explanation of the Machine. (See Plate 33, fig. 2.)

"A, represents the chimney coming from the furnace.

"B, the tow-boat.

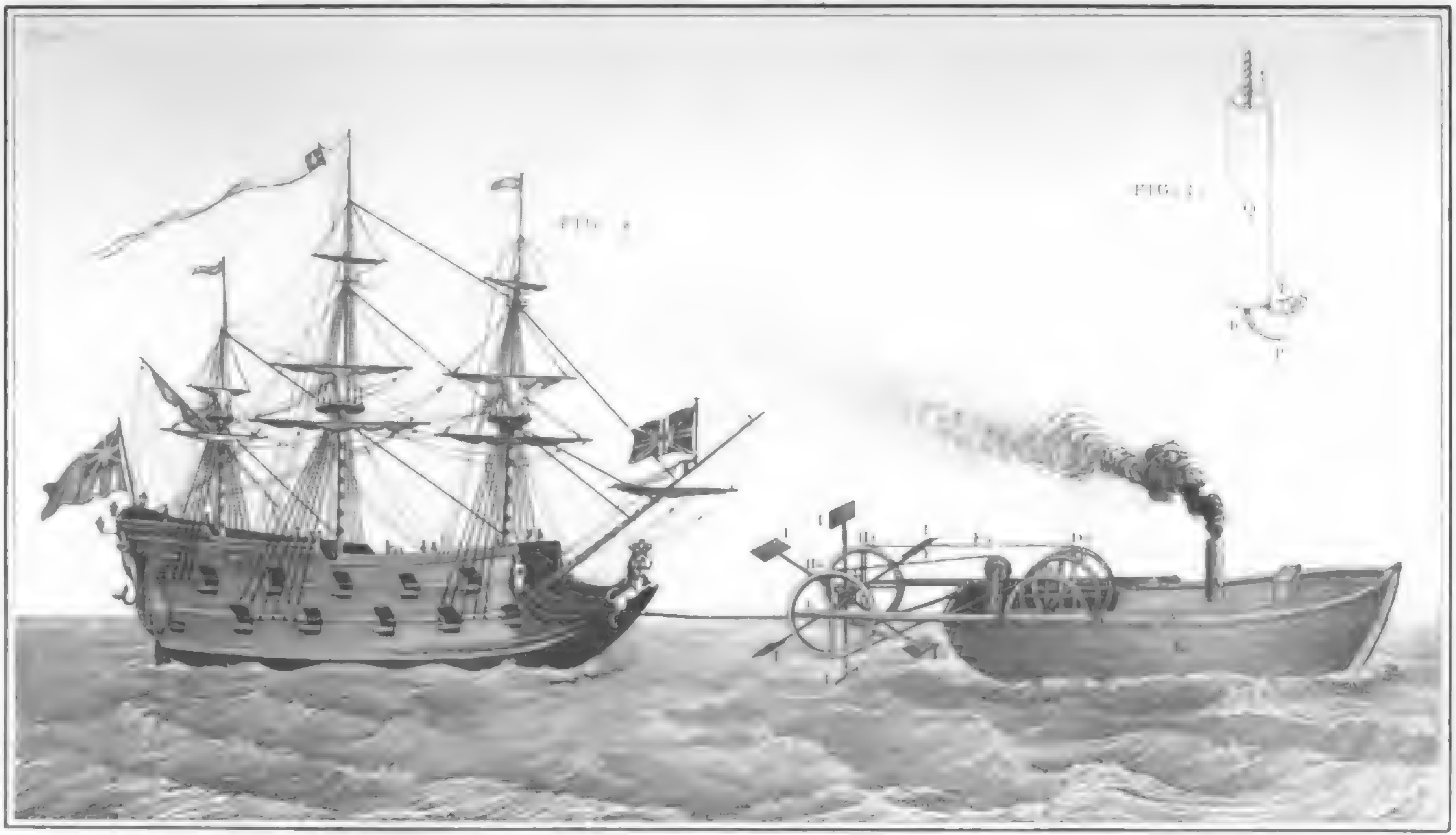
"C C, two pieces of timber framed together, to carry the machine.

"D *a*, D and D *b* are three wheels on one axis, to receive the ropes, M, F *b* and F *a*.

"H *a* and H *b* are two wheels on the same axis, with the fans I I I I I, and move alternately in such a manner that, when the wheels D *a*, D and D *b* move backwards or forwards, they keep the fans I I I I I I in a direct motion.

"F *b* is a rope going from H *b* to D *b*, that, when the wheels D *a*, D and D *b* move forward, moves the wheel H *b* forward, which brings the fans forward with it.

"F *a* is a rope going from the wheel H *a* to the wheel D *a*, that, when the wheels D *a*, D and D *b* move forward, the wheel H *a* draws the rope F, JONATHAN HULLS' STEAM BOAT. INVENTED IN 1736.



and raises the weight G, at the same time as the wheel H *b* brings the fans forward.

"When the weight G is so raised, while the wheels D *a*, D and D *b* are moving backward, the rope F *a* gives way, and the power of the weight G brings the wheel H *a* forward, and the fans with it, so that the fans always keep going forward, notwithstanding the wheels D *a*, D and D *b* move backwards and forwards, as the piston moves up and down in the cylinder.

"L L are teeth for a catch to drop in from the axis, and are so contrived, that they catch in an alternate manner, to cause the fans to move always forward, for the wheel H *a*, by the power of the weight G, is performing its office, while the other wheel H *b* goes back, in order to fetch another stroke.

"*Note.*—The weight G must contain but half the weight of pillar of air pressing on the piston, because the weight G is raised at the same time as the wheel H *b* performs its office, so that it is in effect two machines, acting alternately by the weight of one pillar of air of such a diameter as the diameter of the *cylinder* is."

A few facts may be mentioned, tending to show how talent and ingenuity were converging to the point which has since been reached, in the power and appliances of the steam-engine for navigation. About ten years after Jonathan Hulls had taken out his patent in England, M. Bouguer published his *Traité du Navire* in France; and, considering the importance of having some means to use more effectually than anything that had yet been tried in large ships, as a substitute for the power of wind on the sails, he suggested that, instead of employing a revolving apparatus that should act upon the water, constructed on the plan of wheels to a water-mill, (considering that these could not be moved with sufficient velocity,) there should be a number of oars or large plane surfaces, from 5 or 6 to 10 feet square, and therefore sufficient to present a surface from 25 to 100 square feet, to overcome the resistance. These blades were intended to be composed of a frame, and two leaves or panels moving within it, on hinges, with liberty to open outwardly to about 25 or 30 degrees, that they might be the more easily moved forwards for each successive stroke, but to close firmly against the frame when the stroke was made. It was proposed to place these obliquely at the sides and on the quarters of a ship; and it was estimated that such a number of these might be used as could not fail of impelling the ship forwards.

The Royal Academy of Sciences at Paris offered a prize, in 1753, for the most advantageous manner of supplying the action of the wind on large ships. M. Daniel Bernoulli, then professor of philosophy at Basle, produced the successful essay, having proceeded on the plan advanced by

M. Bouguer. Euler, and M. Mathon de la Cour, wrote on the same subject; and each proposed the use of floats attached to a shaft, which was to revolve by means of mechanical arrangements within the ship. In Euler's plan, the shaft supported four floats, placed at right angles; and the inboard mechanism for working it was a vertical shaft, with a toothed wheel and pinion, as shown in the annexed sketch (Pl. 34, fig. 1.) M. Mathon de la Cour proposed the use of six floats on each axle, and the intervention of an endless cord, passing over a drum at the end of the axle, which was fastened to the side of the ship, and over a corresponding drum annexed to the frame, to be constructed on the deck for working these paddle-wheels. The physical power of man was the only means looked to for turning these wheels. M. Mathon de la Cour says, "One can hardly think of having other moving power than that of men; horses require for their subsistence too great a quantity of water, hay, and corn; they would be unable to endure the labour, joined to the hardship of the voyage; and they can be employed only with machines too complicated, and taking up too much room. Let us, then, endeavour to draw the greatest amount that we can from the strength of men.

"Nothing is more simple than oars; but if we make them similar to those of galleys, their length and weight make them difficult, embarrassing, and of too slow a motion to obtain an effect which would compensate the toil of the crew in working them.

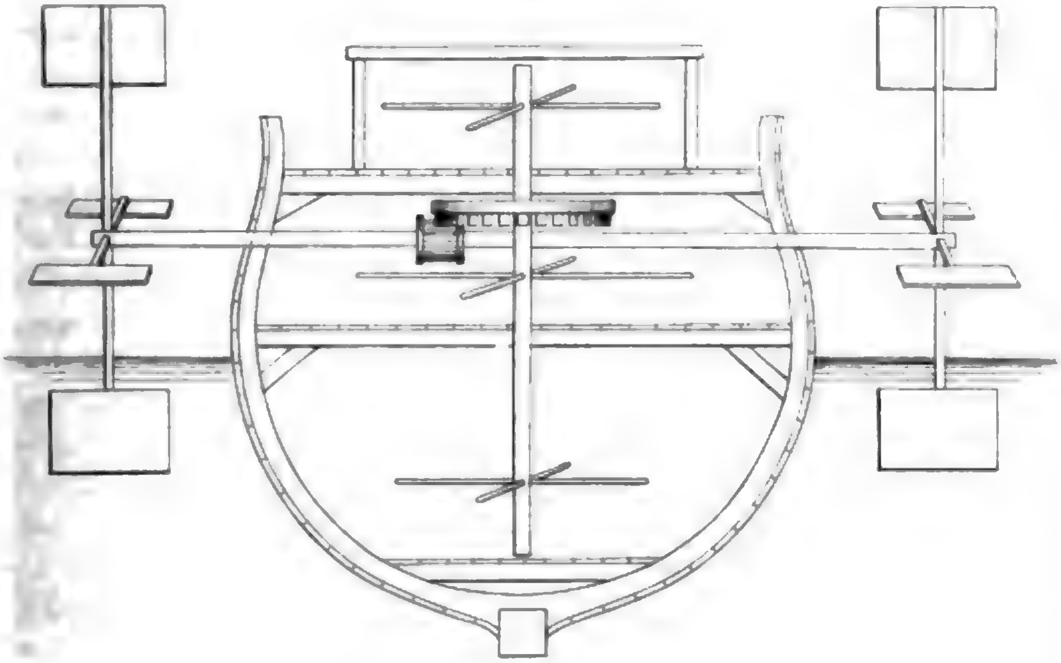
"Most of these inconveniences would be avoided by attaching vertical oars to the two sides of the ship, turning about an axle placed at the most convenient height. The blades should be hung on hinges, which should offer resistance in only one way, and leave a free passage to the water when they were moved in a contrary direction. I reckoned on proposing what appeared to me easy enough; but, under all considerations, I have thought that the unavoidable interruption between the two strokes of the oar, and the resistance that is necessarily experienced in bringing them again towards the bow (the more so, as their motion is then increased by the way of the ship), I have thought that these disadvantages would render their effect much less than that of wheels. Whatever aversion seamen may always have shown to this last means, it cannot but be agreed that it has the advantage of continuity of action, and that the weight of the oars is avoided.

"The question here is only to supply the want of wind, that is to say, to have the means of navigating a calm sea. Wheels can then be used without inconvenience. There is no difficulty in making them light enough to be raised conveniently, and to be unshipped when they are no longer to be used. We will make them of a diameter which will not cover too much of the ship's sides, and which will not obstruct the use of the guns. Finally, we will give them a moving apparatus, which will in some way multiply the

PLANS FOR PROPELLING SHIPS.

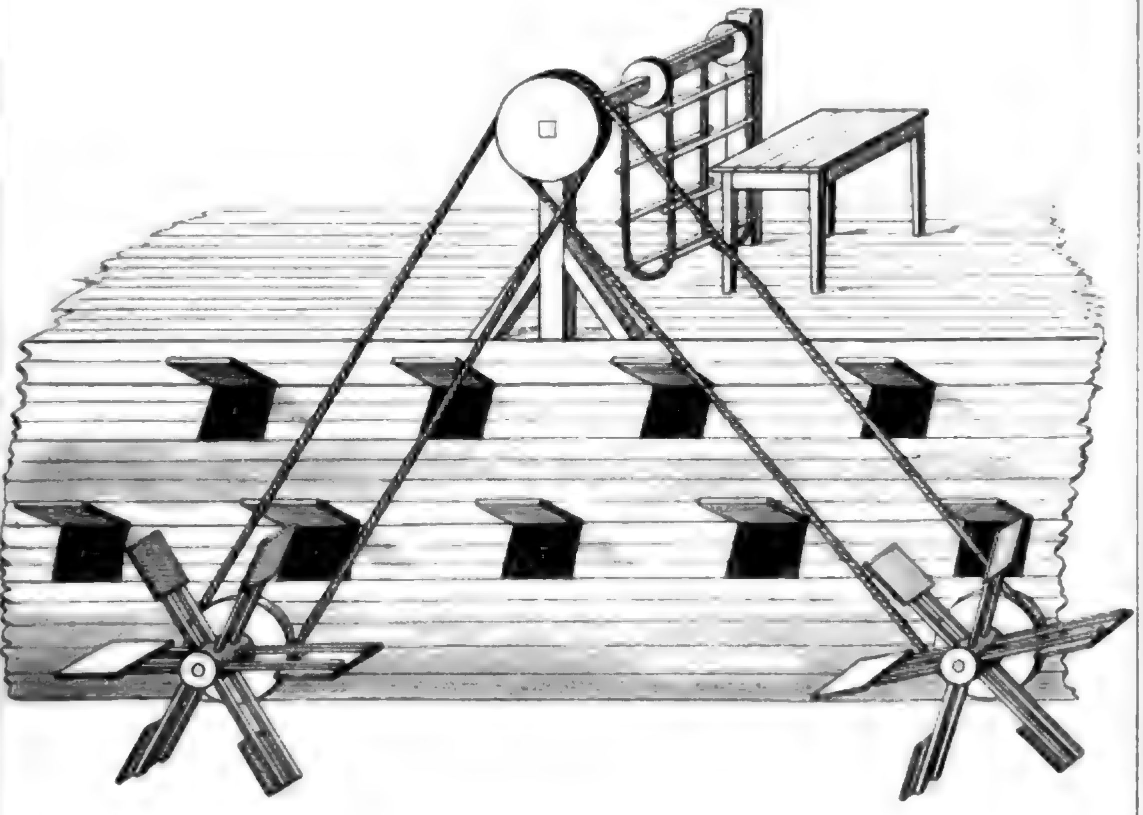
Euler's method of Propulsion

Fig. 1.



Mathon de la Cour's method of Propulsion.

Fig. 2



power of the men without the need of multiplying their number.* They will be placed at the two sides of the ship, their centre being placed about three feet above the surface of the water,—a height to which one may go without danger from the openings and from the ports. They will be of six feet radius, but it will suffice for the blades to be three; for the part nearest to the centre ought not to be plunged into the water." †

Plate 34, figure 2, shows the contrivance proposed by M. Mathon de la Cour.

About the same time, M. Gautier, a regular canon, and senior professor of mathematics, presented to the royal society of Nancy a mémoire, in which he showed that the strength of the crew was not enough to give a great velocity to a ship, and proposed, as the only means of obtaining that object, the employment of a steam-engine, pointing out several ways of applying it to produce a rotatory motion. ‡

But, practically, the steam-engine had not arrived at the stage in which it could be conveniently applied to the purposes of navigation. There were two conditions wanted to adapt it to this object: these were rotatory instead of rectilinear, and continuous instead of intermitted motion. Mechanical contrivances, in the hands of Watt, accomplished these two objects about the year 1781, when he took out a patent for several plans to produce rotatory motion. These were, nevertheless, yet imperfect, as the steam-engine itself gave only an intermitted motion, the defect being supplied by its appendages. But when his plan for the double-acting engine was brought into operation, under the patent dated the 12th March, 1782, the whole effect of continuous motion was produced more simply, and the previous incumbrances avoided. The steam-engine was therefore now rendered fit for the purposes of navigation, in the two features in which it had before been defective. It is, however, right to state, that the importance of supplying these deficiencies was occupying the attention of foreign as well as of English engineers; and different proposals had been made in France to get a rotatory motion, before that object was accomplished in England.

The efforts from which steam navigation ultimately resulted, appear to have been quite independent of whatever had preceded in the same order of invention; for it does not appear from what is recorded of Mr. Miller's investigations and experiments, that he reverted to the plan of Jonathan Hulls. If they had this independent character, then we may date the real origin of steam navigation at 1788; as, in October of that year, an experiment was made upon the lake of Dalswinton, in Scotland. It was a mere experiment, made to ascertain the applicability of steam power to the purpose of propelling a vessel; and, when this had been satisfactorily determined, the engine was removed from the vessel, and she was restored to her common use.

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* It does not appear that M. Mathon de la Cour considered that it was impossible to increase the mechanical power employed without diminishing the speed, an alternative which would cost all the advantage he supposed he would gain.

† Mémoire présenté à l'Académie Royale des Sciences, à l'occasion du Prix de 1753, par M. Mathon de la Cour, de l'Académie Royale des Sciences et Belles-Lettres de Lyon.

‡ Mémoires de la Société Royale de Nancy, tome iii., printed in 1755.

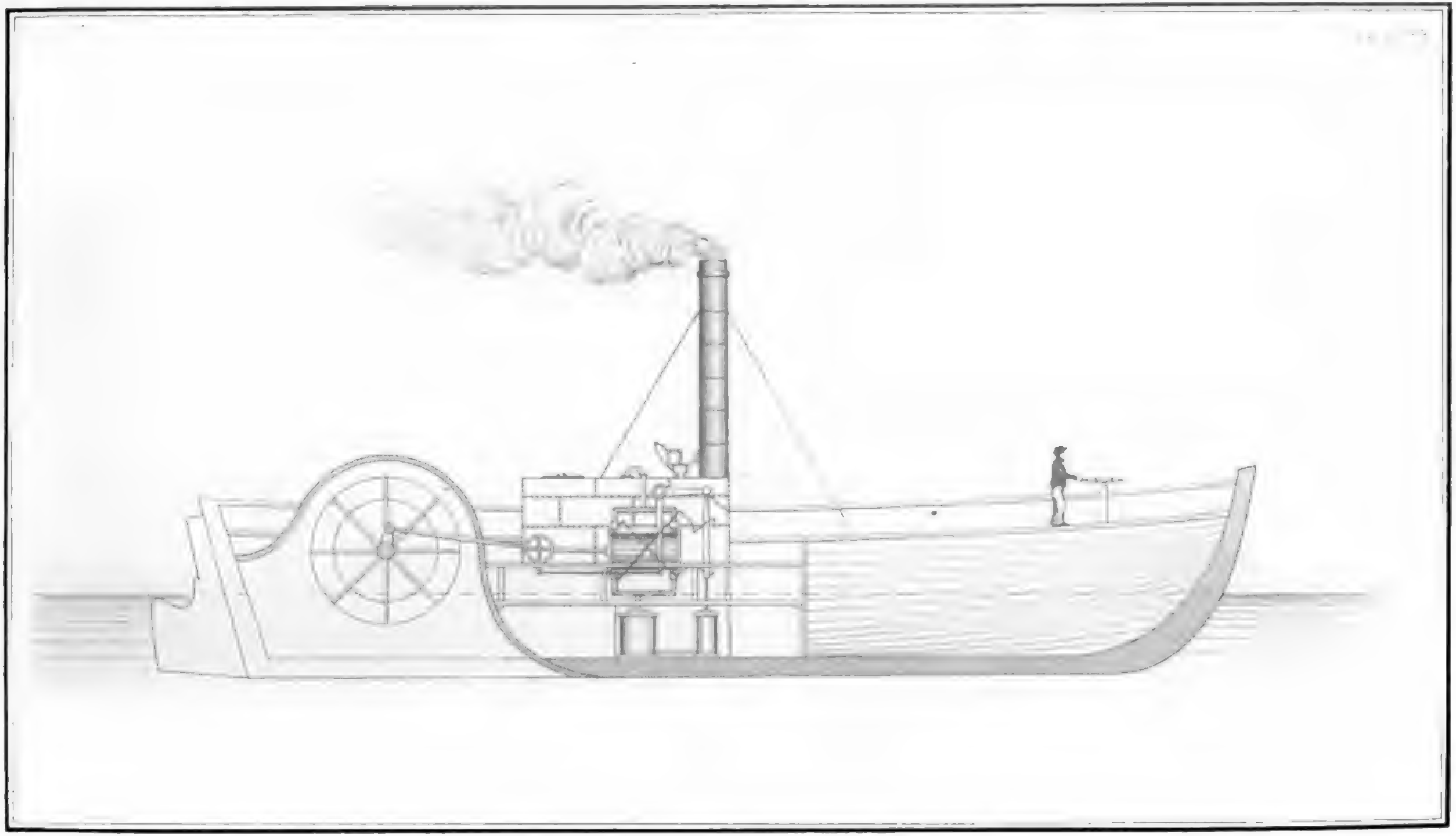
This arrangement seems not to have been the result of any *one* man's thought, but to have been the offspring of the joint labour of three minds,—those of Mr. Miller, Mr. Taylor, and Mr. Symington. Mr. Miller had previously tried the effect of paddles instead of sails or oars; and these were worked by men turning a winch. But this method of propulsion involved a constancy of heavy labour, which it was perceived would be a bar to its extensive application; and, whilst this obstacle was seen to prevail, Mr. Miller was anxious to devise some other means as a substitute for this physical effort. It is recorded that, in the course of conversations which he had on this subject with Mr. Taylor, this gentleman suggested the steam-engine. Neither of them was, however, an engineer; and Mr. Symington, an engineer, an intimate friend of Mr. Taylor's, was consulted. Mr. Symington had already constructed a locomotive steam-engine; and he perceived with what facility a similar engine could be applied to the working of paddles affixed to a vessel. He was, therefore, engaged to share in the undertaking.

Mr. Symington now caused a small engine of about one-horse power to be constructed, suited to work the paddles for propelling Mr. Miller's pleasure-boat. The cylinder of the engine was about 4 or 5 inches in diameter, but with this small power, the vessel was propelled at the rate of five miles an hour; and, in every respect, the result of the experiment was as satisfactory as the size of the vessel and the power of the engine would permit.

After this particular success, it was thought desirable to determine, by an experiment on a larger scale, whether the application of the power would be as favourable, under altered circumstances, with the view to establish grounds of conclusion in favour of the general suitableness of the steam-engine to this purpose, if the results should be similar. Mr. Miller's large pleasure-boat was the subject of this experiment; this vessel was 60 feet in length. An engine of twelve-horse power, having cylinders 18 inches in diameter, was erected at the Carron-works, under the superintendence of Mr. Symington. But the *description* of engine, and all the arrangements in fitting up the vessel, and in connecting it with the paddle-wheels, were identical with those used in the first experiment, with the exception of their being on a larger scale.

Every preparation that was deemed necessary having been made for conducting the experiment upon the Forth and Clyde canal, the engine was set in motion; but the concussions of the paddle-boards against the water were too violent for their strength, and they broke. These were replaced by others of greater strength; and the experiment was fairly made

SYMINGTON'S CANAL TUG BOAT.



on the 26th of December 1789, and repeated with the like success on the following day,—the vessel being propelled at the rate of nearly seven miles an hour. Nothing more than an experiment had been contemplated in the construction of this engine, and in using the pleasure-boat to try its adaptation to the purpose; when, therefore, the results had verified the original expectations regarding the arrangements, the engine was removed from her, and she was restored to her ordinary use.

It appears that Mr. Miller deemed it sufficient to have expended a large sum of money in bringing his experiments to so satisfactory a result, and to have achieved so much towards benefiting his countrymen, if they chose to direct their efforts in the path that had been pointed out to them; for he paid no further attention to the subject. Those who had co-operated with him were not men of capital; and hence, the project of using steam and paddles in propelling vessels was suspended for several years. The invention was, however, established; and the practical application only remained to be made, and those improvements which experience might suggest to be introduced into the arrangements, to render this invention one of the most useful discoveries of modern times.

It may seem strange that there was not a sufficient connection of scientific and mechanical knowledge with capital and enterprising genius in Great Britain, at once to give effect to so grand a design; but the facts of history show there was not: for any further effort appears not to have been made towards this end, till about the year 1801 or 1802, when lord Dundas formed a design to employ steam-tugs, instead of horses, to tow the vessels upon the Forth and Clyde canal. Mr. Symington was engaged by him to construct a steam-boat for this purpose; he completed this undertaking in 1802. The experimental employment of this vessel was satisfactory; for, with an engine having a 22-inch cylinder, with a stroke of 4 feet, she towed two loaded vessels, of seventy tons each, directly against a strong breeze, at the rate of three-and-a-quarter miles an hour; and, when she had no vessels in tow, her speed was six miles per hour. But it was apprehended that the use of steam-boats would injure the banks of the canal; the employment of them for this purpose was, therefore, suspended for some years, until a more independent effort could be made, and the error of the objection determined. The form of the longitudinal section of the tug constructed by Mr. Symington for lord Dundas, is shown in Plate 35; in which it will be seen that the paddle-wheel was aft, and the steersman forward.

It may be deemed a somewhat remarkable fact, that no idea seems to have been entertained by those who took the earliest interest in bringing steam-boats into use, of putting them to purposes more important than the navigation of canals. This may perhaps account, in a great measure, for the very small amount of attention which they received for some years after their capabilities of usefulness had been proved.

The idea of using steam for the purpose of navigation had a floating existence in America, a considerable time before the application of it was successful. The employment of paddle-wheels having been suggested, Dr. Franklin regarded them as unsuited to the purpose, considering that they would be immersed up to the axle, and that, therefore, there would be a great loss of labour in working them.* But the idea of propelling vessels by means of a column of water pumped in at the bow, and forced out at the stern, seemed to him less open to objection, and he thought it possible that a steam-engine might be used to give this motion.

About the year 1783 or 1786, Mr. Fitch tried to overcome the obstacles which seemed to forbid the use of paddle-wheels, by using an apparatus for propelling vessels, something in the shape of shovels, with a steam-engine as the moving power. But the steam-engine was able to give a velocity of only about two-and-a-half knots. In 1787 he built another boat, which performed several passages on the Delaware; and some of Mr. Fulton's opponents reported that she realized a speed of five, six, and even seven knots. But the machinery was subject to frequent derangements, causing a large outlay to the shareholders, who, perhaps, seeing little prospect of ultimate success, gave up the speculation. About 1791, we find Mr. Fitch at Lorient, endeavouring to introduce the use of steam-boats into France. But appearances, which at first seemed to countenance his project, afterwards obliged him to give up his design. Before this time, however, as well as afterwards, there appear to have been some independent efforts to realize steam navigation in France, as "the Abbé Darnel in 1781, M. de Jouffroi in 1782, and M. Desblancs in 1802 and 1803, proposed or constructed new steam-boats." †

About the year 1784, Mr. Rumsey, under the encouragement of Dr. Franklin, began a course of experiments, in employing a steam-engine to pump the water in at the bow of a boat, and to force it out abaft. It was reported that, by the year 1787, he gained a velocity of 2¼ knots; but as the plan was not eventually successful, Mr. Rumsey left his native land to seek for more encouragement in England; and we find him pursuing his investigations at London about the year 1805. In reference to these experiments it may be observed, that Mr. Watt, who was engaged in putting Mr. Rumsey's plan into effect, said afterwards, that the power was applied to great disadvantage, the tube through which the water was forced out being considerably smaller than the bore of the pump-barrel.‡

Another course of experiments was carried on by Mr. Morey, between 1790 and 1797, in which the steam-engine was employed to give motion to various sorts of oars, and particularly to paddle-wheels placed either at the sides or at the stern of a boat. He did not succeed in gaining enough support; or, perhaps, the engineers of America did not, at that time, sufficiently understand the construction of the steam-engine, to bring such a plan to a successful result. We see that, several years later, Mr. Fulton having resolved to make a great effort at placing steam navigation upon a practical basis, ordered his steam-engine at Soho, before he left Europe.

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* Letter to M. Leroi, 5th April, 1775.

† Mémoire sur les Bateaux à Vapeur des Etats-Unis d'Amérique, par M. Marestier.

‡ Buchanan's Practical Treatise on Propelling Vessels by Steam, &c., page 54, Note.

The next important experiments in America, that we find on record, were those of Mr. Livingston. His idea was, that a horizontal wheel, placed at the bottom of a boat in a situation similar to that of a pump-well, being turned very rapidly, would draw the water up through the centre, and that the effect of its centrifugal force would be to expel it through an opening at the after part of the boat, with sufficient energy to acquire the needed velocity.

The state of New York agreed, in 1798, that he should have a privilege for twenty years, on condition that, by the 27th March 1799, he should produce a boat having a velocity of four miles an hour. The time expired without success; and, in 1799, he obtained an extension of two years, in which several other plans were tried,—as paddles, helical surfaces,* wheels on the principle of windmill-sweeps, endless chains with paddles affixed to them, and some others; but still he failed of success.

In 1802, whilst he was filling the post of ambassador, from the United States, in France, he became acquainted with Mr. Robert Fulton, who was already known to some extent in Europe, as the author of several plans which indicated the order and character of his talent, and pointed him out as one with whom Mr. Livingston could act advantageously in his future enterprises. So early as 1793, Mr. Fulton had formed a design for a steam-boat, during a residence of some years in England. In this time he acquired a knowlege of the experiments which had been made in this country; and particularly of the boat constructed by Mr. Symington, which he saw in full action, and carefully inspected. Mr. Livingston informed him also of what his own countrymen had attempted: and the papers of Mr. Fitch came into his hands.

Mr. Livingston's connection with him was advantageous to both. The talent and enterprising character of Mr. Fulton, and the resources available to Mr. Livingston, were thus united. Mr. Livingston obtained from the state of New York, in their joint names, a further extension of two years, from April 1803. With a prospect so encouraging, Mr. Fulton constructed a boat early in that year, which was launched upon the Seine; but, having machinery very heavy in relation to her strength, she broke in the middle, and sank. On being got up, repaired, and re-fitted with her engine, she realized a velocity of 3.58 miles an hour. Strong in the confidence which this success inspired, Mr. Fulton left France, intending to return to America, passing through England. He remained here till late in 1806; and, before setting out for America, he ordered of Messrs. Boulton and Watt, a steam-engine of 20-horse power, to be sent thither. The term on which the privilege had been renewed, having again expired, he got a further renewal of it in the spring of 1807, and launched his first boat.

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* Mr. Robertson Buchanan says of this means of propulsion, "Some mechanics still think favourably of it, and suppose that if a screw of only one revolution were used, it would be better than where a larger thread is employed." Practical Treatise on Propelling Vessels by Steam, &c., p. 45.

The engine was fitted in this boat by the end of August, and soon afterwards she made her first passage from New York to Albany.* The velocity obtained, with the advantage of an open space to navigate, was only equal to that exhibited in the first effort made in Scotland; and about two miles an hour less than Mr. Fulton had witnessed in Mr. Symington's performance upon a canal: the average speed in going and returning was that of about 5¼ miles an hour. The introduction of steam navigation into America was so decidedly successful, that ridicule was put to confusion, and fame and influence followed as rewards to the author of its introduction.

Mr. Fulton began the construction of steam-boats by giving an excessive length in relation to the breadth: the *Clermont*, built in 1807, was 9.33 times as long as she was broad; and, when she re-appeared on the river in the spring of 1808, after the alteration, she was 9.38 times. The second boat that was built at New York, the *Car of Neptune*, had greater relative breadth,—the length being only 7.44 times her breadth. And the change went on gradually in this way for some time; when the length of the *Savannah*, built in 1818 for the navigation of the ocean, included only 3.84 times her breadth. For it came to be conceived that greater relative breadth would diminish the draught of water; and also that it was necessary to longitudinal strength. The concentration of weights about the middle, so much in excess of the proportion which the vessel would bear, distributed through her length, required the support of greater strength. And they considered, that it would be less advisable to obtain that greater longitudinal strength by increasing the materials, than by diminishing the length in relation to the breadth,—seeing that the increase of materials would increase the expense, the weight of the vessel, and her draught of water; and so, the resistance becoming greater, any advantage in point of velocity would be questionable. The same transition is not observable in the early history of steam-vessels built at Philadelphia, Baltimore, and other places. Those of Baltimore, had, however, the less relative length; and this varied in several boats between 6.64 and 4.03 times the breadth. The depth of hold seems to have been determined more by the particular service of the vessels than by their length and breadth and other considerations: in the early vessels it varied between 7 and 10 feet. The draught of water was generally small; the object in determining this condition seems to have been to fit the vessels for the navigation of shallow waters. It varied from about 4 feet 3 inches to about 7 feet;—the *Fulton, Chancellor Livingston,* and *Connecticut* drawing above 6 feet. The *Savannah* drew 14 feet: and the *Robert Fulton,* which was built in 1819, for the navigation of the Mississipi, drew 10.

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* Most of the facts relating to the introduction of steam navigation into America are gathered from a 'Mémoire sur les Bateaux à Vapeur des Etats-Unis d'Amérique,' etc., par M. Marestier, Paris, 1824.

The position of the paddle-shaft varied much in different boats; in most of them it was considerably before the middle; the limits appear to have been from one-third the length to half the length from the bow.

The power of the engines was generally small in relation to the tonnage of the vessels. The first boat had about eight tons to one horse-power; and, when steam navigation had been well established in America, the same ratio seems still to have been approved for small boats,—the relative power of the engines increasing in a small ratio as the tonnage of the vessel increased; and vessels from 400 to 500 tons had five tons to the horse-power. Their very small scantlings, involving comparative weakness in the boats, may have made it absolutely necessary to fix a favourable limit to the weight of the engines in relation to the tonnage of the vessels. The effect of this relatively small power of engines was, a low speed in the American steam-boats generally, for a number of years. The *Clermont's* speed was about four nautical miles an hour; the *Washington,* with twenty revolutions of the paddle-wheels in a minute, went at the rate of five nautical miles an hour; and the speed of the *Maryland,* with seventeen revolutions of the wheels in a minute, was seven miles an hour: the average speed of a number of those which were built during the first twelve years of their history, falls between these two limits.

The earliest steam-vessels built in America had flat bottoms, and scarcely any curvature in their sides; and, it was not until about six years' experience had been gained, that boats were constructed with a form approximating to that of common vessels. The *Fulton* was the first steamer of which the floor-timbers were rounded, and the extremities shaped similarly to those of sailing vessels. Her length was 133 feet, breadth 30 feet, and draught of water 6 feet 3 inches; and she was intended for both sails and steam power. In the same year (1813), the *Washington* was built, after the old model, with a flat bottom. Change, however, went on more extensively after the death of Fulton in 1815; and, in April 1818, the *Savannah* was launched, having been built in the style of a common ship of three masts. Her length was 100 feet, breadth 26 feet, light draught of water 12, and load draught, 14 feet. She was intended for Russia; and was sent to St. Petersburgh, calling first at Liverpool, performing the passage partly by means of steam and partly by that of sails. She did not, however, remain in Russia, but returned by a more northerly course from Europe to America, and reached New York in twenty-five days after having left Norway.*

Hitherto, the American steam-vessels had attained to but a low velocity: the performances of several of the largest of them give a mean velocity, varying from five to seven nautical miles an hour. Fulton considered that eight or nine miles an hour was the maximum of speed that could be given to steam-vessels. But the course of experience, and the energy of enterprize, gradually improved the class of steam-vessels in America; and at length they became not only a most commodious means of travelling, but also very expeditious. The *President*, plying between New York and Providence, is stated by professor Renwick to have had a mean velocity, in performing her passages, of 10.32 nautical miles an hour.

The news of Fulton's success in America, reached this country; and suggested, to a person of similarly enterprising disposition, the probability that he, too, might obtain eminent advantage by establishing the same kind of communication upon the river Clyde, between Glasgow and Helensburgh. This person was a Mr. Bell, the proprietor of an hotel at the latter place. The vessel which was built for him was called the *Comet;* she was 40 feet long on the keel, 10 feet 6 inches breadth of beam, 25 tons in burthen; and was fitted with an engine of about three-horse power. This was the first steam vessel that was employed in Europe for the conveyance of passengers. It is observed, that the relation of her power to her tonnage was very small; hence, she did not obtain a velocity equal to her requirements,—being only about five miles an hour. She began to ply on the river at the commencement of the year 1812. The *Comet* was furnished with two sets of paddles, or two wheels on each side.

The river Clyde, which was distinguished as the scene of her operations, was destined soon to witness the eclipse of her splendour; for, in March 1813, another steamer, of larger dimensions, and higher power, was started, with a direct view to rivalry, and succeeded in bringing an ample remuneration to her projector. The vessel obtained a velocity of nine, and under favourable circumstances, very nearly ten miles an hour, having had given to her a proportion of power, about such as extensive and long experience has since approved as suitable. This vessel was named the *Elizabeth ;* she was 58 feet long "aloft," and 11 feet broad amidships. Her best cabin was fitted up in a superb style; and as she plied regularly between Glasgow and Greenock twice a-day, the advantages were soon appreciated, in the comfort of travelling, and in the diminished expense, which was only one-third of that in travelling between the same places by coach.

When steam-vessels had thus obtained public confidence, they became the approved means of travelling on the Clyde; the traffic was increased with the accommodation; and still larger and more powerful vessels were built and employed with success on that river. In 1815, the fourth year of their running there, ten vessels were plying as packets for the conveyance of passengers, and still the demand for larger vessels continued.*

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* Treatise on the Steam-engine, by James Renwick, L.L.D., pp. 270-1.

It is a fact worthy of notice, that steam-navigation had thus become well established upon the Clyde before it was at all used on the river Thames. We do not attempt to account fully for this; but there seems to have been a jealousy on the part of the watermen upon that river, at any innovation there; as Mr. Buchanan says, "In the year 1813, a steam-boat was built at Bristol, and plied between that place and Bath. The same vessel, by inland navigation, went to the Thames for a short time, but was prevented by the watermen's company from taking passengers. For that reason, the proprietor returned the vessel to her former situation in Somersetshire."† This prejudice seems, however, to have been soon overcome by some means, for we find that in the winter of 1814-15, a steam-vessel came from the Clyde to London, having passed through the Forth and Clyde canal; and she was employed in the following summer in carrying passengers between London and Gravesend. By this time a company had been formed in London, and was engaged in carrying on and extending the advantages of steam-navigation. In the spring of 1815, Mr. George Dodd purchased for that company the steam-vessel *Argyle* (afterwards called the *Thames*), which had been built by Messrs. John and Charles Wood, in 1814, and employed for some time between Glasgow and Greenock. She was 65 feet long on the keel, had a breadth of beam of 14 feet 6 inches; her paddle-wheels were on the first motion, 9 feet diameter by 4 feet wide, having six floats in each wheel, 15 inches broad, and she was fitted with a 16-horse power engine; her draught of water was 3 feet 6 inches. Being too large to pass through the canal, she made her passage to the Thames by coming round the Land's-end; and Mr. Buchanan says, that in this passage she twice crossed the British channel. She was rigged with a square sail on the chimney, serving for a mast, a fore-and-aft sail to the bowsprit or outrigger, and another on the mainmast. Her average speed, in plying between London and Margate, was seven miles an hour.

In the next year, a still larger steam-vessel was provided for the same line. This was the *Caledonia,* built by the same parties, in 1815. Her length between the perpendiculars was 94 feet; extreme breadth, 15 feet 3 inches; and depth in hold, 9 feet. She had a flat floor, and a square bilge, and was originally fitted with two engines of the collective power of thirty-two horses. This vessel was first employed on the Clyde, and in 1816 she came round the Land's-end to the Thames, where she was for a short time employed in making passages to Margate. The machinery was, however, defective, and she was consequently soon laid up. In April,

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* Buchanan's Practical Treatise on Propelling Vessels by Steam.

† Ibid, pp. 62, 63.

1817, Mr. James Watt purchased this vessel, and fitted her with new engines, boilers, and paddle-wheels, the engines being of the collective power of 28 horses; the paddle-wheels were on the first motion, 10 feet 6 inches in diameter, 5 feet 3 inches wide, having eight floats in each wheel, 18 inches broad. On the 15th of October in the same year, Mr. Watt crossed in her from Margate to the Scheldt, and reached Rotterdam the next day. On the 23rd, he proceeded on a pleasure-trip in her up the Rhine; this was the first steam-vessel that was ever on that river. He reached Coblentz on the 13th of November, and as the vessel drew 4 feet 6 inches water, and the river was very low in that season, she could advance no further.

When the *Caledonia* returned to England, she was employed in some experiments to determine her average speed, and was afterwards sold to the king of Denmark.

The use of steam-vessels having been since introduced into the Thames, it was much promoted by the labours of Mr. William Elias Evans, a man of considerable skill, and of great application to the objects of his profession. He served an apprenticeship as a working shipwright in a private yard at Frinsbury, and became very expert in the best duties of his business. He appears to have studied the *construction* of vessels, at the same time that his chief attention was directed to the practical duty of building them. When he had passed through the term of his apprenticeship he went to London, and there designed and assisted in building a small schooner: this was in the year 1815.

In 1817 he began designing and building steam-vessels; the first of these was built in that year, to be employed as a London and Gravesend packet, and was called the *Sons of Commerce*. This was followed by the *Victory*, Margate packet; the *London*, the *Favourite*, and the *Diana*, all for the Thames.

In the year 1821, Mr. Evans was engaged to build the first two steam-vessels regularly employed in the service of the post-office for the conveyance of mails; these were the *Lightning*, of 205 tons, and 80-horse power; and the *Meteor*, of 189 tons, and 60-horse power. They were both employed with distinguished success on the station between Holyhead and Dublin. He built a great number of other steam-vessels to be employed both in the Thames and in the channel; among others, he built the *Medusa*, which was distinguished by being the first to have engines with oscillating cylinders. One characteristic of Mr. Evans's vessels was their remarkable rise of floor, as the *Union*, Pl. 35, fig. 1,—such that, in some instances, the machinery was obliged to be especially adapted to this condition of their construction, being single engines, and placed on the middle line of the vessel. But, after some experience, he altered the form of his vessels, and gave to his subsequent designs a form such as is shown in Pl. 35, fig. 2, of the *Meteor*. The course of Mr. Evans was remarkably rapid in success;

Fig. 1
The Union

Principal Dimensions

	ft	in
Length between the Perp^rs	75	0
of Keel for Tonnage	68	0
Breadth extreme	12	3
moulded	11	8
Depth in Hold	7	0
Burthen in Tons N°.53		

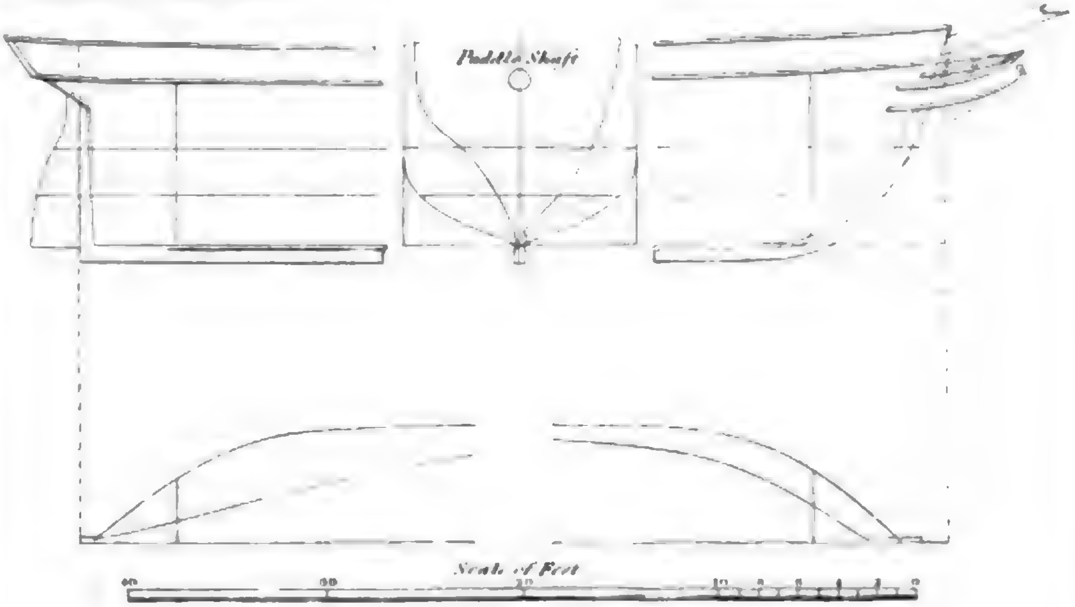
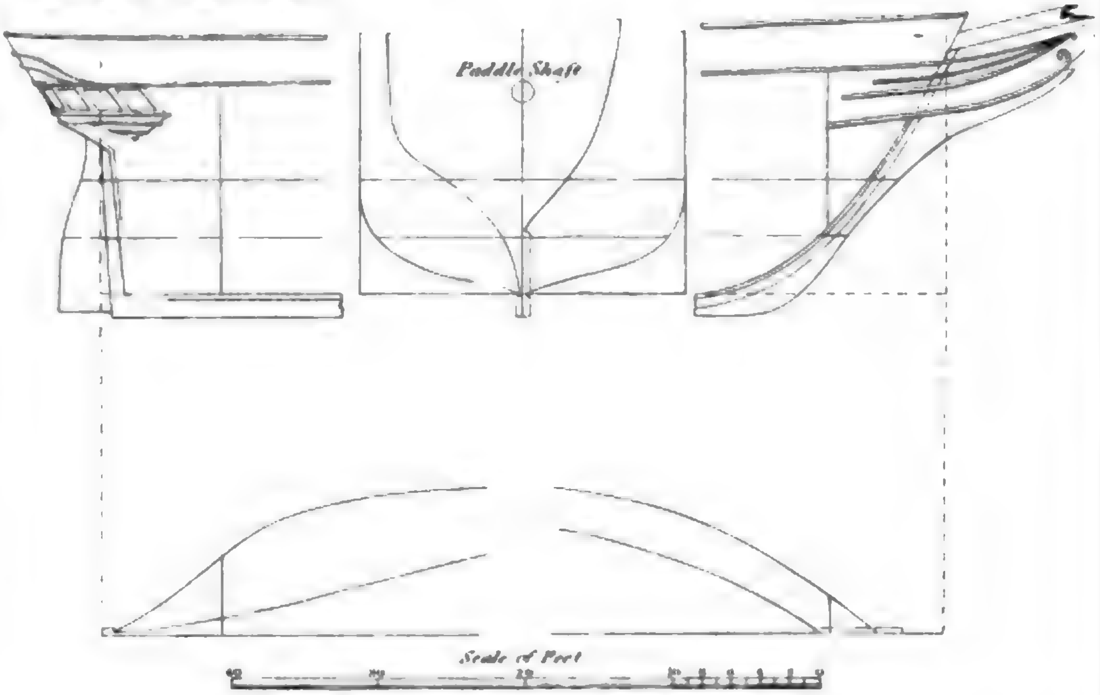


Fig. 2
The Meteor

Principal Dimensions

	ft	in
Length between the Perp^rs	126	0
of Keel for Tonnage	111	9½
Breadth extreme	22	4
moulded	21	10
Depth in Hold	13	8
Burthen in Tons N° 296 [illegible]		

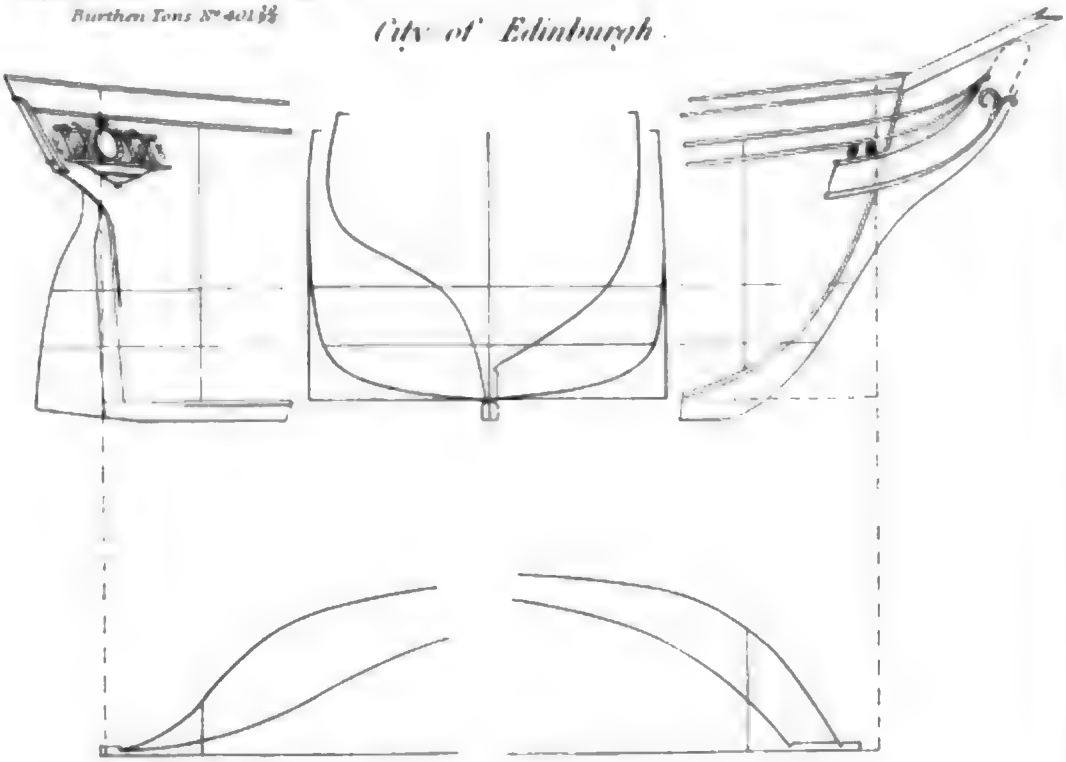


SECTIONS & DIMENSIONS OF STEAM VESSELS.

Dimensions	ft	in
Length between the Perp^rs	133 .	7
" of Keel for Tonnage	116	0¼
Breadth extreme	25	6
" moulded	25	0
Depth in Hold	13	2
Burthen Tons N^o 401 34/94		

Fig. 1.

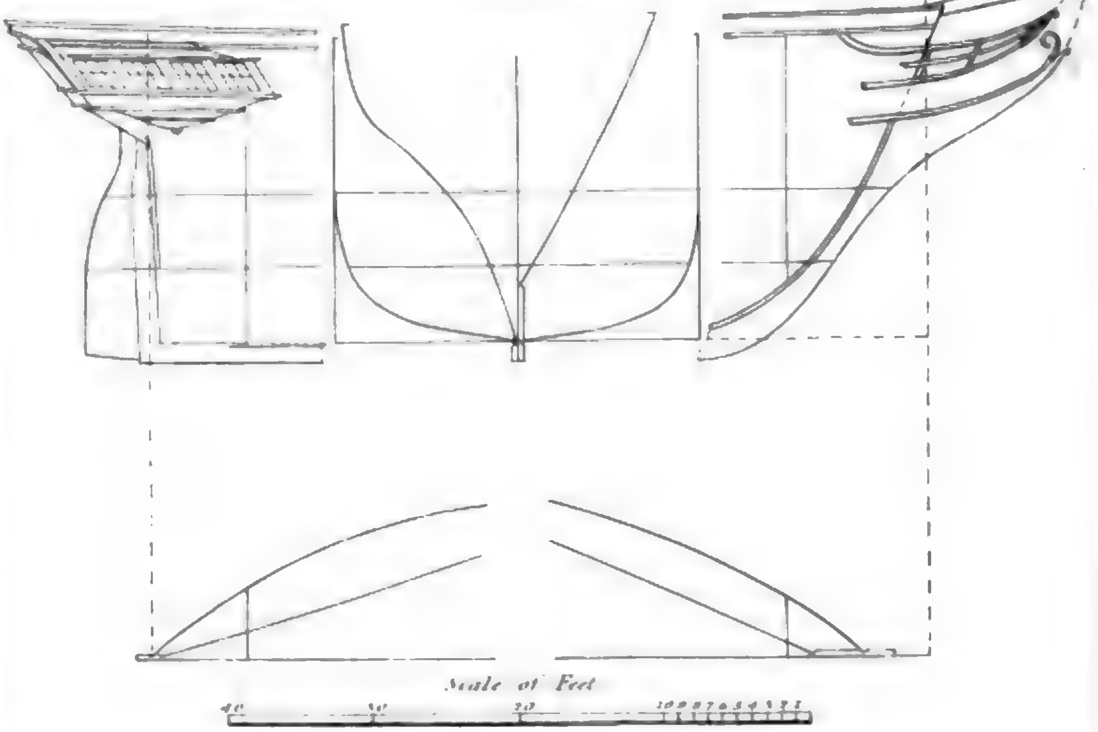
City of Edinburgh.



Dimensions	ft	in
Length between the Perp^rs	142 .	11
" of Keel for Tonnage	126 .	3
Breadth extreme	25	8
" moulded	25	0
Depth in Hold	16 .	5
Burthen in Tons N^o 433 [illegible]		

Fig. 2.

James Watt.



Scale of Feet

the vessels of his construction being numerous, and many of them distinguished by excellent qualities, as well as by the length of service they performed. One of his earliest vessels, the *Union,* with a single engine placed at the middle line, still runs between Portsmouth and Ryde in the Isle of Wight.

Being, at length, desirous to introduce some novel peculiarities into the steam-vessels which he might have to build, his employers opposed his wishes, and he then laid down one on his own account, upon the plan which he had formed. This vessel was afterwards purchased, to be taken to Turin. Another of his steam-vessels was sent to Norway. At last, Mr. Evans himself was engaged to construct and build steam-vessels, upon the plan he had recently adopted, both on the Lake of Geneva and at Marseilles. He died in the south of Europe, having sustained the fame abroad which he had so well acquired at home, by his skill and indefatigable exertions in this one branch of his profession.

Whilst Mr. Evans was pursuing his labours on the Thames, there were others engaged there in carrying out the same useful object. In 1821, Messrs. Wigram and Green built the *City of Edinburgh,* (Pl. 36, fig. 1,) to ply between London and Leith; she was the first vessel which was made to ply in a long sea-passage. Her length between the perpendiculars was 134 feet 9 inches, extreme breadth 25 feet 10 inches, depth in the hold 14 feet 1 inch, and burden in tons $401\frac{30}{94}$. She was fitted by Messrs. Boulton and Watt with two engines, of the collective power of 80 horses; her paddle-wheels were on the second motion, 18 feet in diameter, and 8 feet wide. Each wheel had sixteen paddles, 2 feet broad. The blow-out pipes, brine-pumps, and the bilge injection, were first used in this vessel. Her draught of water, when complete, was 9 feet 3 inches; and her speed, ascertained at the measured mile, was 8.4 miles per hour. In that year, Messrs. Wood, at Port Glasgow, built the *James Watt,* (Pl. 36, fig. 2,) for the same trade. She was 141 feet 9 inches long between the perpendiculars, 25 feet 6 inches in extreme breadth, 16 feet 7 inches deep in hold, and tonnage $420\frac{22}{94}$. The form of this vessel was deemed much in advance of what had been accomplished up to that time; she had her greatest transverse section at the middle of the length, and she would have had sponcings, but that the custom-house authorities insisted on measuring her at the greatest breadth. All her floors crossed the keel, so that she had no half floors. She had two engines, of the collective power of 100 horses; the paddle-wheels were on the second motion, 18 feet in diameter, 9 feet wide; and each of them had sixteen floats, 24 inches broad. With a draught of water of 10 feet 6 inches, her speed was determined at the measured mile to be 10·03 miles an hour. The value of steam-vessels being now clearly proved, the building of them went on; and in 1822 and 1823, a number of others started, amongst which were the *Tourist, Soho, Venus,* and *City of Glasgow.*

The use of steam-boats was now to a considerable extent appreciated in various ports of England as well as of Scotland, and their number, therefore, greatly increased. The city of Dublin soon afterwards availed itself of their advantages, and a company was formed. In 1824 the *Mersey* and *Liffey* were built for them: they went on with energy in the establishment of steam-navigation in Ireland. Most of their vessels have been built at Liverpool, and have been of large dimensions and power.

It was the part of Mr. David Napier, by whom the interests of steam-navigation have been much promoted, to determine the suitableness of steam-vessels to navigate the ocean. This problem was solved by him so early as 1818. Having ascertained the condition of a rough sea in St. George's channel, he considered that steam-vessels could be made capable of bearing it, and prepared forthwith to make the experiment. The result was the establishment of a regular steam communication between Greenock and Belfast: the first packet that plied on that station was the *Rob Roy*, of about 90 tons burden, with a 30-horse power engine. This vessel was employed afterwards to run between Dover and Calais. For when the doubts respecting the practicability of such service had been removed, regular communications were secured, by means of steam-packets running between Holyhead and Dublin, and between Southampton and Havre, as well as between the ports already mentioned.

About four or five years after the adaptation of steam-power to the navigation of the ocean had been tried in the *Savannah*, the question of employing steam-power, in order to obtain a quicker passage between Europe and India, came to be considered both in England and the East. Steam-navigation, once introduced into India, would bear a value which might be estimated by reference to its uses both in Europe and America, apart from the quickness of passage to which it would contribute between the East Indian territories and the mother country. In the year 1823, a number of influential persons in India formed themselves into a committee to encourage, and, under the countenance of the Indian government, to provide the means of rewarding any individual who should make two successful voyages, by steam, to India, with the view to a permanent establishment of that means of communication between the two countries. The Indian government was willing to afford pecuniary aid towards that object. Further, the governor in council at Bombay addressed a letter to the court of directors, presenting a plan for steam communication with England *viâ* Suez. We give the following quotations from that letter, as they show how near to the results of advanced experience the calculations were then made.

"We have for some time past been engaged in inquiries respecting the practicability of opening a communication with England, through Egypt, by means of steam-vessels; and, observing from the public prints that the subject has been also agitated in England, we consider it will be acceptable to your honourable court, to be placed in possession of such information as we have obtained on the subject; and to be assured, in case your honourable court should be disposed to sanction the arrangement, that the difficulties on this side of the Egyptian Isthmus are not greater than on the other.

"The distance from London to Bombay, through Egypt, is not great, but the winds in the different seas that must be crossed are never all fair at any one time; so that, if the passage be good in the Mediterranean or the Indian ocean, it is bad in the Red sea, or *vice versâ*. For this reason, although the whole passage from London to Bombay was once made in two months, yet, it generally takes three months to go from Bombay even to Suez. The great advantage of a steam-boat is, that it is independent of the wind. It would, therefore, go through all the seas between this and England, and at all seasons, nearly at the same rate.

"The average rate on the British seas appears, by the report made to parliament on the subject of steam-vessels, to be about eleven miles an hour: one boat is mentioned as going ten miles an hour against a stiff easterly wind. Taking eight miles an hour for the average rate (which is very moderate, considering that the whole voyage lies through seas little subject to bad weather), and supposing the distance from Portsmouth to the mouth of the Nile (by the Straits of Gibraltar) to be 3000 miles, and from Suez to Bombay as much more (both of which assumptions are considerably above the truth), the time occupied by the sea-voyage would be thirty-one days, the Isthmus might easily be crossed in three days, and the whole would take only thirty-four days; not exceeding, by more than a fortnight, the ordinary period, till lately, required for the post to pass between Bombay and Calcutta.

"We have here alluded to the circuitous communication by the Straits of Gibraltar, because, in time of war, when quick communication is most required, we might not be able to send the packets through France; the probability, however, of our being at once shut out from all the routes across the continent, and all the ports on the European side of the Mediterranean, is extremely small; and, by any of them, the time would be much short of what we have estimated.

"Egypt has seldom or never been so disturbed as to stop our packets; but if it were so, the steam-boats might, for the time, go to some port in Syria on the one side, and to Bussora on the other, so that the packet would still pass with great rapidity, though not so quick as through Egypt.

"It appears to us, on our present view of the question, that two boats on each side of the Isthmus would be quite sufficient to allow of a packet being dispatched regularly every month."*

It does not, however, appear that any immediate success resulted from these proceedings.

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* Letter from the governor in council at Bombay to the court of directors (public department), dated 31st May, 1823.

The first vessel that undertook the voyage, being fitted with steam-machinery and paddle-wheels, was a barque named the *Falcon*, which had been previously a yacht belonging to the honourable Mr. Pelham, afterwards earl of Yarborough. This happened about 1825. But, as the vessel was essentially a sailing vessel, and used steam only partially on the passage, it cannot be regarded as a voyage performed by means of that power; yet, this vessel was the first to exhibit steam-power in navigation in India. The following were her principal dimensions:

	feet.	ins.
Length between the perpendiculars	84	0
Length of keel for tonnage	68	4
Breadth, extreme	22	0
Breadth, moulded	21	4
Depth in hold	11	5

Burthen in tons, $175\frac{84}{94}$.

On arriving at Calcutta, the *Falcon* was bought by the Indian government; the machinery was removed, and she was employed for commercial purposes, as a sailing vessel.

This event was soon followed by the voyage of the *Enterprise*, a steam-vessel of 470 tons, and 120-horse power. Her principal dimensions were, length on the keel 122 feet, and breadth 27 feet; and her paddle-wheels were 15 feet in diameter. She set out from England in August, leaving the land on the 16th, and reached Calcutta on the 7th of December following. The necessity of taking a large stock of coals deepened the vessel, and her speed was considerably less than it had been estimated she would have. The greatest average speed of any twenty-four hours, under the power of steam alone, in a calm sea, was eight knots an hour; under sail alone, or without the aid of steam, it was 8.79 miles; and, with the use of steam and sails together, it was 9.36 miles. Out of the 113 days, between leaving England and arriving at Calcutta, the vessel was 103 days under way, ten days being spent in stoppages for renewing the supplies of fuel, &c. She was fitted up chiefly for the conveyance of passengers, of whom seventeen went out in her. It immediately appeared that it was not advisable, in a commercial point of view, to persevere in the plan which had been thus begun. And, although the *Enterprise* was unfit for such a service as this, and after trial it was seen that she could not succeed in it, there were other considerations which made it doubtful whether steam-navigation to India, *viâ* the Cape of Good Hope, would answer at all as a commercial speculation. When the *Enterprise* arrived at Calcutta, she was sold to the Indian government for £40,000; and the proprietors were thereby nearly indemnified. Steam-navigation was now fairly introduced into India; and it was made the means of executing some very important services for the East India company, in conveying despatches from Calcutta to Rangoon, during the Burmese war, and was eminently valuable in aiding the operations of that campaign. One of the earliest of these services was that of conveying duplicate despatches on the subject of the treaty of Malown, which at once established, in the regard of that government, the importance of employing steam-vessels. Captain J. H. Johnston, who commanded this vessel, says: "Her first voyage to Rangoon and back occupied thirteen days: she left the Sand-heads on the 7th of January, at 5 P.M., and arrived at Rangoon on the 12th of January, at 5 P.M.; the distance, 620 miles: she left the *Elephant*, which is at the entrance of the Rangoon river, on the 14th, at 6 P.M., and arrived at the Sand-heads on the 18th, at 6 P.M. The passage from Calcutta generally occupies two days, from circumstances of tide and shallow water on the Janus and Mary."—"I arrived at Rangoon a week after his majesty's ship *Champion* had sailed with despatches for Calcutta. I returned to Calcutta, took in coals, and was on my way down the river, when the *Champion's* boat passed me with the commander, who had left her at Sauger-roads. My speedy arrival with the duplicate despatch of the treaty of Malown, which I delivered on the fifth day after leaving Rangoon, prevented the government an expense of 600,000 rupees, by arresting the march of troops from the upper provinces, the execution of new contracts for stores and provisions, and the hiring of transports." "Between the 7th of January 1826, and the 20th of the following September, I made six voyages between those places, and a voyage to Chittagon and Akyab; the intervals were employed in river service. The *Enterprise* was afterwards employed principally in conveying troops and stores between Calcutta or Madras and the Tenasserim provinces, or the coast of Aracan; in the conveyance of treasure, and in towing the company's ships and transports to and from sea. Between the 7th of January 1826 and the 18th of April 1829, she made fifty-two communications between different ports, conveying 1970 troops and other passengers, and 2000 tons of stores; she towed eighteen ships to and from Calcutta, and his majesty's ship *Herald* from Calcutta to the south end of Ceylon; she went over a distance of about 28,600 miles. Her average speed, under steam, was 4¾ miles per hour; the average cost of coal about three shillings per mile; her voyages were generally performed in six days from Calcutta."*

The navigation of rivers in India, by means of steam, was a very important, and yet an untried object. The *Enterprise* was not fit to attempt it; but her services, in a freer sphere of exercise, supplied some data towards estimating advantages that might be expected from the extension of steam-navigation into the interior of India, with suitably-constructed vessels. It was a question for consideration, whether the river steamers should not partake more of the character of tugs than of steamers for independent service: there were pressing occasions for the two descriptions of steam-vessels.

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* Evidence of captain J. H. Johnston, before a select committee of the house of commons, in the year 1832.

The *Diana* steamer was employed in India very usefully, as well as the *Enterprise*, in the Burmese war; and this steamer ascended the Irrawaddy river as far as Amarapoura, having on board the British resident and his suite. There was no register kept of the proceedings of this enterprise; but it was stated afterwards, on inquiry, that in going up the river, the steamer generally travelled thirty miles a day,—having to oppose the stream in September. The greatest caution was always necessary in going and returning, for want of a knowledge of the river; and, as the steamer never drew less than six feet water, considerable difficulty was found in returning in December, when the depth of water in the river had diminished.

The next step in the progress of steam-navigation in India, was the building of two boats for river use; the *Hooghly* and *Burhampootur*. The following were the principal dimensions of these vessels.

NAMES.	Length on deck.		Breadth.	Tonnage by measurement.	Power of engines.	Draught of water, fully laden with coals.	No. of hours' fuel, country coal.	Consumption per hour.
	feet.	ins.	feet.		horse-power.			lbs.
Hooghly......	105	2	18	158	2 of 25	4 feet.	94	709
Burhampootur	104	4	18	156	2 of 25	4 feet.	72	709

The building of these vessels seems to have resulted directly from the feeling of want springing up with the extension of British power in India. "Soon after the conquest of Assam, the difficulties of the navigation of the Burhampootur, from the strength of the current and prevalence of east winds, and the want of any ready means of communication by land with the upper parts of the valley, suggested to Mr. Scott the expediency of applying steam to secure the desired facilities. It was reckoned, both that the troops in the valley might be more easily supplied in this manner, and that a great reduction might be made in the number kept up, if, through the use of steamers, the means were obtained of moving them quickly in every direction. The secretary in the secret and political department brought these circumstances under the notice of government, in a note recorded in the political proceedings of the 30th September, 1825; and it was resolved, with reference to the opinion of captain Forbes and other intelligent persons cited by Mr. Swinton, to request the honourable the court of directors to forward two pair of boat-engines, capable of being applied to vessels adapted to the navigation of rapid rivers. The power stated as requisite for the purpose, was two twenty-horse engines for each vessel to be built, and it was at first contemplated that both the steamers should be employed in the Assam Valley."*

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* Parliamentary paper, No. 735, sess. 1832: Note by H. T. Prinsep, esq., secretary to the Bengal government.

In compliance with this request, the court of directors instructed Mr. Maudslay to make such engines; but, as he considered that the power named would not be sufficient for the work they would be expected to perform, he made each of the engines of the power of twenty-five horses. The engines were sent to India in 1826; and plans were sent out with them, for the boats in which they were to be fitted. But, on the supposition that the vessels would not be commodious enough for the conveyance of troops, and also that the draught of water would be diminished by altering the plan, Mr. Seppings, son of the late sir Robert Seppings, the company's marine surveyor, proposed alterations for these two boats. With regard to one of them, proposals for alterations were entertained, and the Howra company built the *Hooghly* "without crooked timbers, and with a rectangular section across." The *Burhampootur* was built by Mr. Kyd, according to the plan sent from England. These two vessels were ready for service in the early part of 1828; and the *Burhampootur* was intended to be employed in the valley of Assam, whilst it was thought better to employ the *Hooghly* in more general service.

Whilst the question of the particular employment of the steam-vessels already provided in India was occupying attention there, the governor-general, lord William Bentinck, who had then just arrived in India (July, 1828), deemed it better to take a more extended view of the subject of steam-navigation in relation to the wants of India, before any definite plan of service was carried into effect on a small scale. A committee was therefore appointed by the government for the purpose of discussing, in all its bearings, the establishment by government of a sufficient number of steam-tugs, to ensure the more speedy and safe navigation of the river Hooghly. The various and great advantages that were expected to result from such a measure, were pointed out in the report in which their discussion terminated. And they proposed that government should equip the *Enterprise*, *Irrawaddy*, and *Ganges* as steam-tugs; and in the event of that proposal not being entertained, they advised that steps should be immediately taken to establish two tugs of the following burden and power: one of about 270 or 280 tons burden, and furnished with two engines of 80-horse power each, and copper boilers; the other to be from 200 to 250 tons burden, with two 60-horse engines.

The delay required for the further consideration of steam-navigation, at the wish of the governor-general, suspended the operations but a short time; for early in September the *Hooghly* set off on her experimental voyage, under the command of Captain Johnston, of the *Enterprise*, to explore the river Ganges up to Allahabad, and reached that place, a distance of 798 miles from Calcutta, on the 1st October; the average speed having been about 3½ miles an hour, and the rate of the current rather greater than that. The *Hooghly* left Allahabad on the 3rd October, and arrived at Calcutta on the 17th, the average velocity having been nearly seven miles an hour. "On some occasions," captain Johnston says, "we went at the rate of ten and twelve miles per hour; on others, as in cases of shoal water, narrow passes, &c., we were obliged merely to drop at the rate of one or two miles per hour.

"The experience of the voyage leaves me confirmed in my belief, that the Ganges may be advantageously navigated by steam-vessels. I think it very desirable to make another experimental voyage in the driest season, and, being experimental, it may be made with advantage through the Sunderbunds." * The further experiment was the more desirable, as the vessel had not been under good command of the rudder; this, coupled with the want of knowledge of the river, made it difficult to judge what might be fairly expected as to the time in which the passage would be made with more efficient pilotage. The boats were but very partially suited to the services required of them in the rivers; and it was perceived to be difficult to unite in the same boat "the three indispensable qualities, lightness of draught, speed, and capacity," for low-pressure engines were used in all the boats then in India. Captain Johnston proposed therefore to supply the desideratum by the use of high-pressure engines. Whilst the experimental expedition of the *Hooghly* was considered to have been made under almost all possible disadvantages, the result "furnished sufficient data to prove both the advantage and ease of steam-navigation, in point of celerity and security, over every other method then in use upon the Ganges." †

The *Hooghly* made her second experimental voyage up the Ganges in the spring of 1829, under the command of captain W. Warden, of the company's marine, leaving Calcutta on the 17th of March. The point at which the river ceased to be navigable to the steamer was Kutchwa, a short distance above Benares,—a distance by the river of nearly 1000 miles. This point was reached on the 9th of April, and the return was made in thirty days, the vessel reaching Calcutta on the 10th of May.

On the 9th of January, 1830, the *Hooghly* set out on a third experimental voyage, under the command of Mr. A. P. Wall, further to explore the Ganges, with reference to steam-navigation. The passage was made only as far as to Ghazeepore, about sixty-six miles below Benares. Mr. Wall says, "It would appear to me to be scarcely possible to limit the distance which a vessel of the *Hooghly's* draught shall proceed, in the dry season, up the Ganges, as she is as liable to meet a barrier of sand in the lower as the upper part of the river. I infer this from having found, about two miles below Secregully, a sand extending completely across the river, and the deepest water on it being only five feet in the width of the river to this place, near a mile, and the current not exceeding one mile and a quarter per hour." * The vessel reached Ghazeepore on the 29th of January; and, leaving that place on the 2nd February, she reached Calcutta on the 15th of that month.

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* Letter from captain J. H. Johnston to the secretary of the Bengal government, dated 24th November, 1828.

† Letter from captain T. Prinsep, to the same.

The project of realizing steam-navigation in India was never allowed to fall into depression there. The various measures proposed had been carefully considered, and every effort indicated progress towards that object. The year 1829 was distinctly marked with some of these events, which were yet to be more fully developed. Mr. Thomas Waghorn, who had been sent to this country from India by the government there in 1827, "for the purpose of establishing steam-navigation between England and India," failing almost entirely of obtaining patronage for doing this round the Cape of Good Hope, was advised to turn his attention to the line which was first recommended by the Indian government, and to return to India by the Isthmus of Suez. He therefore left London on the evening of October 28, crossed over the continent of Europe to Trieste, and arrived at Alexandria on the 27th November, at 8 A.M., three days and seventeen hours of the time having been spent in stoppages. A statement of this journey was published, with the view to draw attention to the subject.

In the same year the *Hugh Lindsay* steam-vessel was built at Bombay, and was launched on the 14th of October. She was built after a design that had been sent from England, for an armed steamer in the Indian navy. Her principal dimensions were as follows: length of the keel 124 feet 5 inches, and breadth of beam 24 feet 10 inches,—the length being about five times the breadth. She was 411 tons, builders' measurement, and was fitted with two 80-horse power engines. She was intended to carry five and a half days' coal; and with that, she drew 11 feet 6 inches water.

Towards the close of that year, a prospectus was issued by a Mr. J. W. Taylor, whose object was "to establish a regular communication, by means of steam-vessels, navigating the Mediterranean and the Red sea, between London and the different presidencies of India. The experience afforded by passages made by steam-vessels on certain parts of the route selected, justifies the expectation that intercourse between the two countries may thus be effected in from fifty-four to sixty days." † Already Mr. Taylor had been engaged four years in forming his plans; and, in association with gentlemen in England, in providing the means to carry them into effect. He had then just performed a journey from England to India *viá* Suez. He says, "I beg leave respectfully to inform your excellency, that the requisite number of steam-vessels being already built and equipped, a commencement may be made on the proposed line of communication within three months from the period, when the assent of your excellency's government to my propositions may be made known to me.

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* Letter from Mr. A. P. Wall to captain J. H. Johnston, dated 12th April, 1830.

† Prospectus of an establishment of steam-vessels, dated 1st December, 1829.

"If then I should be honoured with such assent, it is my intention, within the period already specified, to be the means of introducing into British India such a number of first-rate steam-vessels, unexceptionable in point of size and equipment, as will enable me to propose myself to become a general carrier to all the Indian governments, both for England and in India, and will admit of those governments maintaining a constant and regular communication with Great Britain, and all principal parts of British India, on the 1st and 15th of every month." *

The result of this and other communications, addressed by Mr. Taylor to the government at Bombay, was an official letter from them to the court of Directors, stating that they considered the "honourable court alone competent to pass a decision on his proposals;" but they strongly recommended to the countenance of the court the project which he was endeavouring to accomplish. "We beg to add our opinion that no doubt can exist of the practicability as well as utility of extending steam-navigation to Egypt from Bombay; and that we should consider it a most fortunate circumstance, if our attempts to promote this desirable object shall, by indicating such to be the case, induce men of enterprize and capital to embark in an undertaking of the nature proposed by Mr. Taylor.

"The plan proposed by Mr. Taylor evidently requires great and combined means to give it even a prospect of success; we are of opinion that his calculations are far too sanguine, and that his plan is on too large a scale. These are, however, objections to his scheme that may easily be obviated. In the first instance, we must give our opinion as relates to India, that the undertaking may and should be conducted on a more limited scale, and subsequently extended according to circumstances. On the degree in which Mr. Taylor possesses the means of carrying his plans into effect, or can command them, we have no opportunity of judging; but this we deem of little importance, as your honourable court can easily determine this point.

"In transmitting these proposals for your consideration, we cannot avoid expressing our decided opinion that almost incalculable advantages may be anticipated from a well-established steam communication by the Red Sea, and our earnest hope that, unless other proposals of individuals have been entertained, and their plans put in progress, and in case Mr. Taylor's schemes are viewed as either inexpedient or impracticable, that every support will be afforded by your honourable court to maintain this desirable communication by vessels in the public service." †

The temper of the court of directors is somewhat strikingly in contrast

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* Letter from Mr. J. W. Taylor to sir John Malcolm, governor of Bombay, dated 1st December. 1829.

† Letter from the Bombay government, in the marine department, to the court of directors, dated 18th April, 1830.

with the earnestness of the Bombay government. *Nearly two years* after the great importance of establishing a line of steam-packets between England and India had been thus urged on the attention of the court of directors, they set about answering the letters they had received on that subject. The expense exceeded what they were willing to risk; they had little confidence that the vessels and engines which might be provided would turn out well, not regarding the probability that improvement would advance along with experience,—as they say, "the loss from defective vessels or engines is as likely as ever to occur." They nevertheless affirmed, that they were "not insensible to the advantages of a rapid communication with India, and of the importance of encouraging the application of steam to that purpose.

"We are also disposed to believe that a steam communication by the Red Sea, and still more, if it should be found practicable, by the Persian Gulf and the river Euphrates, would open the way to other improvements, and would ultimately redound to the benefit of this country as well as of India; and if our finances were in a flourishing state, we might possibly feel it a duty to incur even the enormous outlay which we have specified.* But in the present condition of our resources, we cannot think the probable difference of time in the mere transmission of letters a sufficient justification of such an expense. We cannot anticipate that the return in postage and passengers would pay more than a very small portion of the charge.

"These considerations induce us to pause before we determine the great question of engaging in any project of this character at present; not seeing our way clear to such a result as would justify the expense, we shall not authorise any further steps in the matter.

"At the same time we deem the subject too important to be lost sight of, or hastily dismissed." †

The *Hugh Lindsay* was, however, engaged to make a passage from Bombay to Suez and back, and was in the actual performance of that object, in April, 1830, when the letter was written by the government at that place; and this passage had been twice repeated, as will be shown presently, before the court of directors gave any instructions on the subject.

The following passages from the pen of commander J. H. Wilson, of the Indian navy, who commanded her in the four voyages from India to the Red Sea, will show in what way the steam navigation of that line was begun: "When it was determined that she should attempt the voyage to Suez, it became necessary to put on board double the quantity of coal the vessel was built to carry, to do which, a great part of the space originally intended for accommodation was appropriated to the stowage of coal; water also was necessary, sufficient for use, until the vessel should reach land, in the event of a break-down with the engines between Bombay and the first depôt; as also stores and provisions for the whole voyage to and from the Red Sea. With all this, in a vessel originally intended to carry five and a half days' coal, and every thing else proportionate, and drawing 13 feet 6 inches instead of 11 feet 6 inches, the *Hugh Lindsay* started for the Red Sea on the 20th March, 1830, colonel Campbell, of the Bombay artillery, being the only passenger. A post-office packet was conveyed, containing 306 letters, the postage of which amounted to 1176 rupees. The coal depôts were Aden, Judda, Cossier, and Suez. At first starting from Bombay, the engines made 11½ revolutions, and the distance actually run by chronometers gave about five knots an hour; more, of course, appears by log, from the wash of the paddles. The season was rather an unusual one, for from the Bombay bank, until to the westward of Socotra, light westerly breezes were experienced, but the water was generally smooth. On the 31st March, at 1 p.m., the *Hugh Lindsay* anchored at Aden, with only about six hours' coal remaining, having performed the passage, a distance of 1641 miles, in ten days nineteen hours; the latter part of the stage the engines making nineteen revolutions, and the vessel going good eight knots. Much delay and inconvenience was experienced from paddle-boats and boards getting loose. Scarce a day passed without the engines being stopped to set them right; and of the ten days nineteen hours occupied on the passage, nine hours forty-seven minutes were lost in stoppages. At Aden we were detained five days and twenty hours in receiving the necessary quantity of coal, owing to the want of means at the place for shipping it, and other obstacles.

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* £100,000 per annum.

† Letter from the court of directors to the governor in council at Bombay (public department), dated 14th March, 1832.

"On the 6th April, at 9 A.M., left Aden for Mocha, having on board despatches for that place, and on the 7th, at 9 A.M., anchored in Mocha roads. The weather from Aden to the Straits had been pleasant, with smooth water: from the Straits to Mocha a fresh southerly breeze was experienced. It must be observed, the vessel lay-to some time before daylight, to avoid passing the port, or a better run would have been made, the engines having made seventeen revolutions, and the vessel averaged seven knots.

"On the 8th, at half-past 5 A.M., started for Judda with a light breeze and smooth water, the engines making eighteen revolutions, and the vessel going about seven knots and a half. On the 10th, a north-wester set in, which, varying in strength, continued till we arrived off Judda, at times reducing the revolutions to eleven, and the way actually made to about three knots. One of the pieces or arcs of the paddle-circles was lost in this stage of the voyage, as before mentioned, and one of the holding-down bolts broken. On the 12th of April, at 6 P.M., anchored off Judda, having made the passage from Mocha, distant 557 miles, in four days twelve hours.

"On the 17th, having been four days and a half at Judda, owing to the dilatoriness of the agent in sending off coal, we left for Suez, with variable breezes and smooth water, the engines making seventeen revolutions, the vessel going about seven knots. On the 18th, a north-wester set in, which continued till the 21st, varying in strength, at times reducing the revolutions to ten and a half, and the vessel's rate to scarcely three knots. The north-wester having taken off, in running up the sea of Suez, with smooth water and a light northerly breeze, the revolutions increased to twenty, and the vessel's rate to nine knots. On the 22nd April, at a quarter past 8 A.M., the *Hugh Lindsay* anchored in Suez roads, having performed the voyage from Bombay in twenty-one days six hours' steaming, and thirty-two days sixteen hours, all stoppages included. At this time, had a steamer been in readiness at Alexandria, three days would have conveyed the packets there, from whence, in twenty-five days, they would have reached England. Thus, notwithstanding all the delays at the depôts, the communication between India and England would have been accomplished in *sixty-one days*. This first voyage, therefore, was anything but a failure as far as the *Hugh Lindsay* was concerned; and, looking only to the time occupied in steaming, was very satisfactory. As no arrangements were made on the Mediterranean side of the Isthmus, it would have availed little, however quick the voyage from Bombay to Suez had been made."

The passage from Suez to Bombay was performed partially under circumstances quite favourable as to time. The necessary supply of coals having been taken in, the *Hugh Lindsay* left Suez on the 26th, at half-past 5 P.M., and arrived at Cossier on the 28th, at half-ast 8 A.M. It must be noted that the engines had been on half-power from midnight till daylight, as the port could not be entered in a dark night.

"On the 30th April, having received a small quantity of coal, and there being no passengers, quitted Cossier for Judda, where we arrived on the 9th May, at 4 P.M. On this stage, variable winds were experienced till near Judda, when a strong north-wester sprang up, but the engines were on half-power the night previous to making the shoals off that port, it being dangerous to approach them except in the day-time.

"On the 6th May started for Mocha, at which place communications for the presidency were to be received from the agent and the surveying vessels in the sea. On the 9th, arrived at Mocha, having experienced throughout the stage variable southerly breezes. A supply of tallow being requisite, some difficulty was experienced in procuring it, and the vessel detained two days in consequence.

"On the 12th May, started for Aden, and arrived there on the 13th. Here, nearly six days passed in getting on board the coal, from the weather being unfavourable, and the want of boats and men at the place.

"On the 19th, at half-past 5 A.M., started for Bombay, where we arrived on the 29th May, having performed the voyage from Suez in nineteen days fourteen hours' steaming, and thirty-three days, all stoppages included. It is clear, therefore, that as packets could be brought from England to

Alexandria in twenty-five days, and from thence to Suez in three more, the *Hugh Lindsay* would, in this instance, have brought packets from home in *sixty-one days*, notwithstanding the great portion of time lost at an anchor. It must be admitted no very bad weather had been experienced on the passage to Suez, and on the way back from Aden to Bombay, the westerly winds and favourable currents having set in, expedited in some degree the performance of that stage of the voyage; but still, with co-operation in the Mediterranean, the result of the voyage would have been very encouraging."

In the following December the *Hugh Lindsay* made a second passage from Bombay to the Red Sea; not, however, to Suez, but to Cossier, 300 miles from the isthmus, on the bank of that sea, and about 100 miles from Ghenna on the Nile: she was seventeen days in performing the passage, and five days at anchor,—together, 22 days. In January, 1832, a third passage was made from Bombay to the Red Sea, extending to Suez. The practicability of the passage was now demonstrated as to the most favourable seasons, that is, during the prevalence of the north-east monsoon; but it was by no means certain, from the performances of the *Hugh Lindsay*, that the passage could be made irrespectively of the seasons, or in the south-west monsoon. That vessel was not fit to make so bold an experiment as it required to decide this question. Her construction and power were not suited to contend against the south-west monsoon, from Ceylon or Bombay to the strait of Babelmandel.

Captain James Henry Johnston and lieutenant Thomas Waghorn are the two gentlemen by whose intelligent and vigorous exertions the subject of steam navigation to India was presented to the English nation, in its best phases of desirableness and practicability. Mr. T. L. Peacock, of the India-house, devoted a great amount of careful attention to the collecting of information on this subject, and he was brought to the same decided opinion of the practicability of that passage as captain Johnston and Mr. Waghorn.

But captain Wilson of the *Hugh Lindsay*, who must be supposed to have had the greatest experience of any one at that time on that subject, was of a contrary opinion; for he affirmed, very confidently, that it was not practicable to maintain a steam communication between India and Suez during the south-west monsoon. An article, written by him, and printed in a parliamentary paper in 1834,* is full of statements and arguments aiming to discredit those contained in an address printed by lieutenant T. Waghorn, on the practicability, desirableness, and advantage of establishing a regular communication by steam between Europe and India. It is not necessary now to say that events have refuted the soundness of captain Wilson's arguments; for they have added one to the host of proofs, that it is unwise in any person to affirm the impracticability of what *he* cannot do, if he has no other data than his own experience, or rather *want* of experience, to rest his arguments upon. In this case, it was merely negative evidence, and experience soon proved it to have been misapplied. Mr. Waghorn gave it as his opinion, that neither the *Enterprise* nor the *Hugh Lindsay* could perform the passage against the south-west monsoon; but that "a steamer built for the purpose could do it."

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* No. 478, session 1834.

In the year 1832 the subject of steam navigation, both *with* and *in* India, came to be more thoroughly inquired into, when the affairs of the East India company were under investigation by a select committee of the house of commons. In that inquiry, the whole circumstances of the transactions affecting this object were brought out. Much valuable information on the subject was communicated by Mr. Peacock, of the East India-house, who had made himself acquainted with almost every thing that had been done, both in developing the feasibleness of the plan which had been before the Bombay government, and in the facts of what had been practically accomplished.

When experience had proved the value of internal steam navigation in India, it became necessary to consider how far the difficulty of navigating the rivers might be diminished, by diminishing the draught of water of the vessels; as there were certain limits beyond which the vessels already so employed could not go, which might, as it appeared, be exceeded by vessels drawing less water, with a greater power of engines, whilst such would be far better amongst the shoals and other difficulties generally in the river navigation. The *Hooghly* and *Burhampootur* had but partially met the wants of the service; and, as it seemed that iron vessels could be built which should draw less water than wooden vessels, orders were given by the East India company for two vessels to be built of this material in England, that its suitableness might be tried, as to its lightness, and the speed of the vessels also ascertained here, under the required conditions of construction. They were to draw 2 feet water; one to be a steam-tug-boat, the other an accommodation-boat, both of the same dimensions,—120 feet long, by 22 feet wide, flat-bottomed. The engines were to be two of thirty-horse power each, with vibrating cylinders, on account of lightness. On the result of the experiment to be made with this pair of boats was suspended the decision of the directors, as to the building of other similar boats—four pairs of such having been considered necessary, if they should fulfil their intentions. These were then to navigate the interior of India, leaving the *Hooghly* and *Burhampootur* to navigate the lower part of the river. The Indus too, with the other rivers of the Punjaub, presented a wide scene for inland navigation, which might be realised by steam-vessels with much higher results than the common craft of the country could effect. We see in these early efforts an approximation to what has been really accomplished;—for the success of the first effort at getting a very high power of engines in relation to the draught of water led to the building of other iron boats, of similar description, by

Messrs. Miller and Ravenhill, Mr. Laird, and Messrs. Forrester and Co., to be employed in the same way. The effects which followed the use of these boats have been, extended intercourse with the natives, increase of trade, and economy and expedition in the transport of troops.*

When the use of steam-vessels was so far advanced in India as to give a practical bearing to the project of extending it from Bombay or Calcutta to Suez, the route by the Persian gulf and the river Euphrates came to be more seriously considered, as that line would not be subject to obstruction by the south-west monsoon. The physical capabilities of the line were generally ascertained; at the same time, the uncertainty attaching to the political conditions of the countries which would have to be passed through, made it undesirable to enter hastily upon a plan which should risk the safety of passengers who might embark in the vessels, by selecting that line of transit. Further, the necessity of the packets' lying at anchor during the night, would make the passage of the river tedious; so that, even if the distance were so much shorter than it would be to Suez, as to make it on that consideration desirable, the journey would be the more wearisome, as much time must elapse which would bear no account in performing the journey. It may be sufficient now to observe, that the line by the Euphrates appeared desirable on scarcely any other supposition, than that of the impracticability of reaching Suez at all times of the year. Whilst, therefore, a doubt remained on that subject, the Euphrates was always looked at with interest by many who were desirous that England and British India should be mutually benefited by steam communication.

Practically, the subject seems to have made no further progress for some time. Two years elapsed, and the question, involving so great consequences, was taken up by the house of commons, and a "select committee was appointed (in 1834) to inquire into the means of promoting communication with India, by steam." The practicability of expeditious communication between Bombay and Suez had by this time been brought to the test of experiment in five seasons, during the north-east monsoon, at the expense of the Indian government; but, up to that time, it had not been tried in the period of the south-west monsoon. During eight months of the year it was practicable; but, for the rest, further experience was needed.

Before this time, steam navigation had become the established means of conveying the mail between Falmouth, Malta, and Corfu, vessels belonging to the government being used as the packets. The means thus existed on this side of Egypt, to co-operate with what it was sought to provide, and what was in the course of development, beyond that;—needing, however, some extension of arrangements to realize the full results.

Up to the beginning of the year 1830, sailing packets were employed in that service: these required about three months, on an average, to perform the passage from Falmouth to Corfu; the mean rate of sailing, in a considerable number of voyages, being only 2·7 miles per hour.

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* For a fuller account of steam navigation in India, see Appendix, No. 1.

On the 5th of February, 1830, the *Meteor* government steam-packet left Falmouth with the mail for the Mediterranean, and instead of taking three months to reach Corfu, she arrived at Falmouth on her return, in forty-seven days, being about one-fourth of the time. The packet that left England in the following month was conveyed by a sailing-vessel; the *Osborne* left Falmouth on the 6th of March, and reached Corfu on the 13th of June; but the *Echo* steam-vessel, which left England on the 6th of April, had reached her destination and returned; and even the *Meteor,* which conveyed the mail from England in May, delivered her charge before the *Osborne* arrived, and was again in England in nine days after the sailing-vessel reached Corfu. Perhaps few of the early services of steamers in conveying the mail-packets, exhibited more strikingly the relative superiority of steamers to sailing-vessels than was shown in these passages.

The *African, Carron, Columbia, Confiance, Echo, Firebrand, Hermes, Messenger,* and *Meteor* were regularly employed in monthly passages from Falmouth to Corfu, till June, 1832. The longest passage out and home was that of the *Meteor* (fifty-five days) in May and June, 1831; and the shortest was that of the *Messenger* (thirty-six days) in August and September, in the same year: the average was about forty-five or forty-six days, including all stoppages,—at Cadiz, Gibraltar, and Malta twice, and Corfu once, on each voyage, making together about thirteen days expended in stoppages. On the 9th of July, 1832, the *Meteor* left England with the mail, having for her ultimate destination Patras, in the Morea. The average time of twenty-one voyages out and home, was forty-nine days; but the *Alban,* in a voyage not included in this average, was absent sixty-nine days, having had to encounter strong gales, generally adverse. The stoppages occupied about twelve days. The arrangements of this country needed, therefore, but little addition to co-operate efficiently with any plan beyond the isthmus for the establishment of steam navigation between England and India.

In this state of steam navigation, the committee recognized the importance of making the line complete to India. And they said, "It is expedient that measures should be immediately taken for the regular establishment of steam communication from India by the Red Sea;" and as to carrying that object into effect, they were of opinion that it should be left to the British "government, in conjunction with the East India company, to consider whether the communication should be, in the first instance, from Bombay or from Calcutta, or according to the combined plan suggested by the Bengal steam committee;" and that "the net charge should be divided equally between his Majesty's government and the East India company, including in that charge the expense of the land-conveyance, from the Euphrates on the one hand, and the Red Sea on the other, to the Mediterranean." In the uncertainty of being able to navigate the Euphrates during the whole year, as well as of steaming from India to the Red Sea against the monsoon, it was considered "eminently desirable" that the practicability of navigating the Euphrates at all seasons should be ascertained, in order that the advantages which were represented to be in the prospect of that event might also be realized; and it was suggested, that by occupying each line in the respective periods when the physical difficulties had disappeared, the passage might be easily made throughout the year; "the physical difficulties on the line of the Red Sea appearing to be confined to the months of June, July, August, and September; and those of the river Euphrates to the months of November, December, January, and February." The committee recommended to the government an extension of the line of Malta packets to such ports in Egypt and Syria as would complete the communication between England and India.

The government began, therefore, immediately to carry these objects into effect; the first thing was to give directions to the admiralty to complete the monthly communication of packets in the Mediterranean, by sending a steam-packet from Alexandria to Malta; this was done in August, 1834. And this arrangement was carried into complete effect in February, 1835. About the same time that the government directed the admiralty to extend the line of packets to Egypt, the court of directors sent out instructions to the governor-general of India to send the *Hugh Lindsay* at stated periods to Suez. During this time the character of the Euphrates was still further explored by colonel Chesney, under the sanction of the India board, to whom that object was confided by parliament; and the governor of Bombay, and afterwards the home authorities, established a dromedary post from Bagdad to Damascus, and from Damascus to Beyrout, for the more rapid transmission of mails between England and India. The beneficial effects of these arrangements were soon felt in India, as the Bombay government noticed in a despatch to the court of directors, in September, 1836, in which they say, that "the three last overland mails have brought despatches from London to Bombay in 58, 45, and 64 days; and those intended for Calcutta have been forwarded in ten days." The despatch containing this information, and bearing date the 16th September, 1836, did not reach England till the beginning of the following year, as the steam communication between the two countries had not been established with regularity, nor with a frequency which satisfied the public wants. The delay in carrying the plans into full effect, was owing partially to the continued uncertainty whether the route by the Euphrates was feasible, and if so, whether it would be advisable to give the preference to it; and this decision could not be arrived at, apart from the information which colonel Chesney was employed in getting.

The Peninsular steam navigation company was, however, formed; and before the government took measures to establish a regular and frequent communication with India by steam, they opened a correspondence with that company, which had in view the line of communication from England to India. After some delay, the committee of that company made their report, in which was the following statement.

"The company propose to despatch monthly from England a steam-vessel, of competent power and size, to touch at Cadiz, Gibraltar, Malta, and Alexandria, taking to those places his Majesty's mail-bags, &c., as now performed by the government vessels; the postage relating to those mails remaining, as at present, in the hands of his Majesty's government. That the most efficient plan be adopted by the company for the transmission of despatches, letters, &c., to India, across the isthmus of Suez, to meet the proposed company's vessels in the Red Sea, from whence, in the first instance, it is intended they should be forwarded to Bombay. That a vessel start also every month from Bombay to the Red Sea. That all government despatches and letters to and from India, together also with a messenger (if so required), be taken, free of every charge whatever, other than the general annual amount hereinafter stated; but all private letters, &c., be chargeable with a sea-postage in favour of the company, and the company protected against private carriage of letters by parcels, &c., as exists in this country; the inland postage in respect of those letters to be in the hands of the government. That the government give the proposed company a contract for a period of years to be agreed upon, and an annual sum of £40,000 for performing the above services; the company entering into a sufficient contract for the regular and proper fulfilment of their undertaking, subject to accustomed risks and liability. That the East India company, in consideration of their despatches being carried by the proposed company, pay £25,000 per annum; a proper contract being also entered into with them for the fulfilment of the engagement.

"The committee, anxious to afford every explanation to his Majesty's government and the East India company, have no hesitation in disclosing their calculation of the expenses attending the performance of the undertaking, which, after allowing only £5 per cent. on capital, amount to the

annual sum of		£136,500
Required of the government as above . .	£40,000	
Ditto of the East India company ditto . .	25,000	
		65,000
Leaving a deficiency of		£71,500

which the company will defray. They will also find the necessary capital, which, in the outset, is estimated at £250,000; but as the other presidencies are brought into the operation, an increased proportionate outlay will be required."

At this time the company was in its most elementary state, having but just organized the plan and opened its share-list. The proposals were referred to the post-office authorities for consideration; and Col. Maberly reported to the postmaster-general, that "the sum that was demanded from the government was altogether out of proportion with the value of the service to be performed," and the cost at which it was then executed. The lords of the admiralty and the India board came to similar conclusions, of the inexpediency of entering into the proposed contracts. The various considerations given to the question brought the matter down to February, 1837, when the court of directors directed their secretary to express to the India board their "opinion that, in order to ensure the efficiency and permanency of steam communication with India, it should be established and maintained by his Majesty's government and the East India company. They desire distinctly to state their readiness to concur in the establishment of a monthly steam communication with India by the way of the Red Sea, upon the principle which was recommended by the committee of the house of commons in 1834, and to which they have on former occasions referred, viz., an equal division of the expense between his Majesty's government and the East India company.

"The court submit, that the expense, to be thus divided, should be the charge which might be actually incurred for the object to be effected; and as his Majesty's government have already a packet establishment for other purposes between Falmouth and Malta, the conveyance of the India mails, to and from Malta, would not be attended with any charge to his Majesty's government. The expense of the necessary establishment beyond that place is, therefore, all that would be incurred on account of India, and, consequently, all which the East India company should be called upon to share.

"The court being, however, anxious that the settlement of this question should be no longer delayed, are willing, as his Majesty's government have extended the packet communication from Malta to Alexandria, to waive the claim which India might possess to a share in the postage, which, in such case, would be received by his Majesty's government to and from Bombay, instead of, as at present, to and from Alexandria." *

When the question was under the deliberation of the lords of the treasury, they came to the conclusion that the line of steam communication ought not to be limited to Bombay, but extended to Calcutta; but as they did not see a prospect of gaining the consent of the directors to that plan, they ultimately acquiesced in that which the directors had proposed, expecting to have a favourable opportunity to extend it to Calcutta, when it should appear, in the course of experience, that the interests of India and England demanded it to be done.

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* Letter from Mr. Melvill to Mr. Gordon, the secretary of the India board, dated 1st February, 1837.

The plan was soon determined on, subject to the limitation proposed by the court of directors; and the arrangements having been concluded, the court sent out, on the 2nd June, 1837, a despatch to the governor-general of India, with directions as to the way in which it was to be carried into effect. It was as follows: "1. We have the satisfaction to acquaint you, that we have concluded an arrangement with his Majesty's government for the establishment of a monthly steam communication between Great Britain and India by way of the Red Sea. 2. His Majesty's government undertake the transmission of the monthly mails between Great Britain and Alexandria, at the sole charge of the public; and we have undertaken the transmission of these mails between Alexandria and Bombay, upon the condition that one-half of the expense which we may incur in the purchase, equipment, maintenance, and navigation of steam-vessels, (including the value of any which we may already possess, and which may be applied to this purpose,) or on any other account for the service, shall be paid to us in London, at the termination of each year, we consenting to relinquish to his Majesty's government the whole of the postage between London and Bombay. 3. It is our desire that this arrangement take effect forthwith, and with that view we shall direct the government of Bombay to send the *Hugh Lindsay* to Mocha, for the purpose of her being regularly employed in conveying the mails between that place and Suez, and to despatch the *Atalanta* and *Berenice* on alternate months to Mocha. 4. We are aware that a fourth steamer will ultimately be necessary, and we shall adopt measures for providing one. 5. We shall immediately contract for the purchase of a large quantity of coals for consignment to Bombay and to Mocha respectively."

The *Atalanta* was 616 tons, builders' measurement, and had two engines of 105 horse-power each. She carried one long gun to throw a hollow shot of 48 lbs, and four of Dickson's 32-pounders. The *Berenice* was $664\frac{4}{94}$ tons, builders' measurement, and had two engines of 115 horse-power each. She carried one long gun, as the *Atalanta*, and two of the smaller guns.

At the same time, whilst the court of directors were unwilling to extend the steam communication with India, at its first starting, beyond Bombay, yet the governor-general was instructed to order an experiment to be made with one of these large steam-vessels, in a passage from Calcutta to Madras and Ceylon, and thence across the Indian Ocean to Socotra, and up the Red Sea to Suez, in order to determine, practically, the result of such an experiment. At the same time that the East India company made the arrangement for the steam-packet communication beyond Alexandria, the board of admiralty made corresponding arrangements for the employment of government steam-vessels between Falmouth and Egypt, at monthly periods, to give effect to what was done beyond that point. These were the steps, and this is the plan, on which a regular, periodical communication between England and the East Indies came to be established for the conveyance of the mails and other things.

The company which was in the course of formation, when both the government and the East India company saw that the time had arrived for requiring a more regular and certain transmission of the mails between his country and the East, went on in the development of their resources and plans; and in September, 1837, the admiralty entered into a contract with that company as the "Peninsular steam navigation company," for the employment of steam-vessels of not less than 140 horse-power, to convey the post-office mails weekly from Falmouth to the several ports of Vigo, Oporto, Lisbon, Cadiz, and Gibraltar. This service was diminished, after seven years and a half, to the sending of a packet three times in a month. Before this time, however, (in September, 1840,) the government had discontinued employing their own steamers on the line between England and Egypt, and had contracted with the same company to occupy this line with vessels of not less than 400 horse-power. In 1843, the East India company entered into an engagement with the same company—now the "Peninsular and Oriental steam navigation company"—for the regular employment of steamers, in running once a month from Suez to Calcutta, for the conveyance of mails and other things; and on the 1st of January, 1845, the government and the East India company together arranged with that company for the employment of ships of larger capacity and higher power on the same line, delivering and receiving packets at Ceylon and Madras. These arrangements did not at all interfere with the original establishment of the East India company's line of packets between Bombay and Suez: the *Acbar, Atalanta, Auckland, Cleopatra, Queen, Semiramis, Sesostris,* and *Victoria* are now appropriated to that service. At a period later by two years, the packet service in India was extended to China also.

Attention seems to have been rather slow, in perceiving both the importance and facility of steam communication between England and North America. The great consequences to these two very enterprising commercial countries, of having quick and certain, as well as regular communication with each other, cannot be easily defined; and yet the practicability of obtaining this had been demonstrated several years before the idea was entertained here with a practical bearing,—demonstrated too by means of a British-built steam-vessel, but with no object in which Great Britain was immediately interested. The *Curaçoa* steamer, of 400 tons' burden, and fitted with two 50-horse power engines, was purchased in England by the Dutch government. She performed the first voyage from Helvoetsluys to Surinam, in 27 days 11 hours; and from Surinam to Curaçoa in 5 days,—32 days 11 hours, in which she steamed 11 days 3 hours. She steamed 23½ days on her return, and performed this passage in 29 days. The average consumption of fuel was 7·14 pounds to a horse-power in an hour. The second voyage out was in March 1828: she started from Helvoetsluys on the 1st of the month, and arrived at Surinam on the 25th of the month, and anchored. The greatest distance run in any twenty-four hours on this passage, was 207 miles, with the power of sails and steam united. The fires were up thirteen days eighteen hours, but steam was employed *alone* only a small portion of this time, whilst the vessel was sailing without steam from the 15th to the 24th of the month, inclusively. The weather was generally favourable during this passage. The third voyage was perhaps better suited to try the fitness of a steamer to navigate the ocean generally, as she had to encounter "several severe gales and hurricanes, during which the machinery worked without interruption or accident."

These voyages supplied data which might be used whenever the spirit of enterprise should make the Atlantic ocean the sphere of steam-navigation, on the part of Great Britain.

In the year 1832 the *Royal William*, of 1200 tons, and 180-horse power, made a voyage from Picton in Nova Scotia, to England, and arrived at Portsmouth, having steamed the whole distance, in twenty days. She had been built at Quebec for a company, to run between Quebec and Halifax, and her engines were constructed at St. Mary's foundry, Montreal; but instead of being employed according to the original plan, she was sold to the Portuguese government.

In 1835, that object gained some attention in England; and the result of that attention was the formation of the Great Western steam-ship company, in 1836. Captain Christopher Claxton, R.N., was one of the most active of the individuals engaged in that object. It devolved on him to collect the information on which the plans and proceedings of the company should be based. It appeared, as the result of all this information, "that, for the purpose of carrying cargo as well as passengers, the most speedy and certain passage, the greatest economy of power, and the best assurance of a profitable return for the capital invested, would require a vessel of at least 1200 tons." * It was estimated that the passage from England to America by a vessel of that size, properly constructed and fitted, would be considerably less than twenty days, and the return made in thirteen days; whereas the average outward passage of sailing-packets between Liverpool and New York was thirty-six, and the homeward passage twenty-four days.

Upon the information thus gathered, and conclusions arrived at therefrom, the company built their first vessel, the *Great Western*, of the following dimensions, tonnage, and power: length between the perpendiculars 212 feet, over all 236; extreme breadth of beam, 35 feet 4 inches; depth of hold 23 feet 3 inches; load-draught of water, 16 feet; burthen in tons, 1340; engines, 400-horse power, constructed by Messrs. Maudslay, Sons, and Field.

The *Great Western* was complete and ready for sea in the spring of 1838, and was advertised to make her first voyage from Bristol to New York, in April. The object of establishing a line of communication between Great Britain and the United States of America, was now regarded as so important, that there were at least three competitors for the honour of making the first voyage across the Atlantic. The first of these was the *Great Western*. She had been completed in her fittings in the river Thames, and set off from London on the morning of the 31st March, on her passage to Bristol, which had been advertised as the port of her departure for New York on the 7th of April. In this passage she was subject to a small accident, in the combustion of some felt, which had been placed too high up on the boilers; and it appears that the alarm produced by this untoward event acted prejudicially to her first passage, as she took out then only seven passengers. The speed on this passage down the channel was, however, most encouraging to the proprietors, the average speed from London to Bristol being 12·88 miles an hour.* The next steamer to contend for this honour was the *Sirius*, belonging to the St. George steam-packet company, and chartered by them to the British and American steam-navigation company, to be employed by them till their new vessel (the *British Queen*) should be ready. The third candidate for this distinction was the *Columbus;* she was, however, too late in her preparations to appear on the scene of actual competition; and the trial was made by the two others.

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* Captain Claxton's Report, 1st January, 1836.

The *Sirius* left Cork on the morning of the 4th of April, 1838, bound for New York, having on board thirty state-cabin, twenty-nine fore-cabin, and thirty-five steerage passengers; and she arrived at New York in the evening of the 22nd. The *Great Western* left Bristol on the 8th of that month, and arrived at New York on the morning of the 23rd. The passage determined the relative powers of speed most conclusively in favour of the *Great Western;* this ship having left Bristol *four days after* the *Sirius* left Cork, and having therefore a greater distance to run by more than 200 miles, she nevertheless arrived eight hours after the *Sirius*. A contemporary journal says, "Their arrival appears to have created even a stronger sensation in New York, than their departure in England; and not unnaturally; the winning-post is always a place of keener interest than the starting-post. In this case also there were two starting-posts, but only one goal." Their return from America confirmed the evidence of the relative merits of the two vessels which had been borne by their outward passage: the *Sirius* left New York on the 1st of May, in the afternoon, and reached Falmouth in the evening of the 18th, being over seventeen days on the passage; the *Great Western* left New York on the 7th, and arrived at Bristol on the 22nd, having run the passage in exactly fourteen days, and beaten the *Sirius* at the rate of about two miles an hour on the passage.* The estimation of which the *Great Western* was worthy, seems not to have been disparaged at New York by the accident which had excited fears before she left England, as she brought home sixty-six passengers, 5,555 letters, and 1,760 newspapers, besides a quantity of merchandise.

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* Civil Engineer and Architect's Journal, May 1838: distance, 670 miles; time, 52 hours, not including 6½ hours' stoppage, on account of the accident.

The *Great Western* kept steadily to her object; and no sooner had her proprietors witnessed the splendid results of their enterprise in the return of that vessel from her first voyage, than they met and determined to build another steam-vessel for the same trade, of even greater tonnage than this ship. She set off on her second outward passage on the 2nd of June, and arrived at New York on the 17th, completing the run in fourteen days sixteen hours, having taken out fifty-seven passengers. Her next return was accomplished in twelve days fourteen hours.

The arrangements for the two rivals in their second voyage did not show the same cutting competition as had marked their first passage outwards; for the *Sirius* had started soon enough to arrive at New York on the day after the *Great Western* left England. After making this second voyage from Liverpool to New York and back, the *Sirius* was taken off the line, and sent early in August with passengers from London to St. Petersburg. The vacancy thus made by the withdrawal of the *Sirius* was, however, immediately filled by the *Royal William*, which left Liverpool on the 5th of July, bound to New York. On the 21st of that month, the *Great Western* left Bristol on her third voyage, carrying out at this time 131 passengers: she performed the passage in fourteen days and eighteen hours.

The *Great Western* continued to occupy the line, irrespectively of competition, although the government refused the tender of the Great Western company for the conveyance of the North American mails, and subsequently contracted with Mr. Cunard to perform that service from Liverpool.

It was in the winter of 1839 that Mr. Cunard came to England, and first proposed his plans to the government for this object; † and the result of that proposal was a contract, that he should establish and maintain, for seven years, a line of steam-packets, of large size and power, to leave Liverpool twice each month for Halifax, and leave Halifax as often for Liverpool, conveying the post-office mails. The effect of this arrangement was a great increase in the facilities of travelling and conveying information, as the number of vessels was required to be such that they could leave at *certain* and short intervals of time. Three vessels were at first supposed to be enough for this service. Mr. Cunard therefore conferred with Mr. Robert Napier, of Glasgow, and forthwith made arrangements with Mr. J. Wood, of Greenock, for the building of the *Acadia*, *Britannia*, and *Caledonia*, and with Mr. Napier for the construction of their engines.

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* Description of the *Great Britain* steam-ship, by captain Claxton, R.N.

† Parliamentary paper, No. 563, session 1846.

The following were the principal dimensions of these vessels, with their power, &c.:

NAMES.	Length between perpendiculars.	Extreme breadth.		Depth in hold.		Burthen in tons.	Horse-power of Engines.	Diameter of Cylinder.	Length of Stroke.		Diameter of Wheel.	No. of tons to 1-horse power.
	Feet.	Ft.	Ins.	Ft.	Ins.			Inches.	Ft.	Ins.	Feet.	
Acadia	206	34	6	22	6	1136	440	72	6	10	28	2·58
Britannia	206	34	6	22	6	1155	450	—	—		28	2·57
Caledonia. . . .	206	34	6	22	6	1139	450	—	—		28	2·53

The conveyance of the mails was paid for at the rate of £2115 from Liverpool to Halifax and back. Experience soon showed that it was necessary to employ four vessels, to maintain this line with efficiency; and in 1844, Mr. Cunard brought into that service the *Cambria* and *Hibernia*, of 1314 tons and 500-horse power, and 1349 tons and 500-horse power, respectively,—the government having agreed to give him £80,000 a-year on condition of his employing five boats, having them also of larger size. The relative power to tonnage was nearly the same in these larger vessels, as that which had been determined for the first that were built for the same service.

The following small table and remarks were published before Mr. Cunard's larger vessels were built, and are quoted for the interesting results exhibited.

Vessel's name.	Tonnage.	Horse-power.	Proportion of tonnage to power.	Remarks.
Acadia	1200	440	1 h. p. : 2¾ tons	Exceedingly fast.
Oriental	1670	440	1 h. p. : 4 tons	10¼ knots when deep.
Great Western . .	1340	450	1 h. p. : 3 tons	
Great Liverpool .	1543	464	1 h. p. : 3⅓ tons	
British Queen . .	2016	500	1 h. p. : 4 tons	Fast when light, and light stern breeze.
President	2366	540	1 h. p. : 4⅓ tons	Slow under any circumstances.
Liverpool (before alterations). . . .	1150	404	1 h. p. : 2⅓ tons	Slow and crank.

"In the above table I have endeavoured to place the vessels in the order of speed—an average westerly passage across the Atlantic being supposed to be the work performed. The *Oriental* and *Great Western* are, I think, about equal—as also the *President* and *Liverpool* (before alterations).

"It will be observed, that though the proportion is the same both in the *Oriental* and *British Queen*, yet it cannot be questioned that on every point, and most especially when the vessels are deep, the *Oriental* has the advantage.

" It may also be mentioned that the *Liverpool* has had seven feet more beam given her, and is now 393 tons larger than formerly; the proportion of power has, therefore, been *decreased*, whilst her speed and weatherly qualities have been materially *increased*.

" Also, the four first and best vessels, and which vary least in their speed, in bad weather, have more beam (in proportion to their length) than the other three.

" It appears to me, that more depends on the *form and construction of the vessel*, than on having a large engine power."*

The small discrepancy in the stated tonnage which this table may show, compared with the preceding table, in which the *Acadia* is stated, according to official documents, to be 1136, instead of 1200 tons, is not sufficient to affect the general principle which this communication was intended to illustrate.

The starting of the *British Queen* and the *President*, though they were inferior in speed, affected this line in a commercial point of view: and, afterwards, when the *Great Britain* began to run (the *President* having, a considerable time before, been lost), the extraordinary character of that excellent ship placed her on an eminence to which she was looked up with admiration by all who were interested in steam navigation.

The Great Western Steam-ship Company having resolved in 1838 to build a second ship, larger than their first, they resolved also to realize in her the utmost extent of improvements that could be obtained. The determined vigour of enterprise, and ample resources of talent which distinguished that company, are too well known to need affirmation here. These means were fully used in the production of the *Great Britain*. The following particulars are taken from captain Claxton's interesting " Description of the *Great Britain* steam-ship."

Vessel's Name.	Length			Extreme breadth.	Depth in hold.	Mean load-draught of water.	Tonnage by old measurement.	Displacement in tons.	Horse-power of engines.
	Of keel.	Between the perpendiculars.	Over all.						
	feet.	feet.	feet.	feet.	ft. ins.	feet.	tons.	tons.	
Great Britain	289	286	322	51	32 6	16	3443	2984	1000

In two respects the building of this ship was a gigantic experiment: in the use of material, and the description of propeller. In comparison of the *Great Britain*, all that had yet been done in the building of iron vessels, was almost in miniature. But, whatever was deficient in experience, was supplied here by sound and intelligent reasoning, in every way reflecting honour on those who deduced their accurate results from so limited premises.

Mr. Paterson, who had built the *Great Western*, furnished the lines for the *Great Britain*; the keel was laid down in July 1839; and, until the works had advanced about seventeen months, it was intended that she should be propelled with paddle-wheels. During this time, the *Archimedes*, fitted with Mr. Francis Petit Smith's screw-propeller, was developing the powers of that instrument. Without entering into the details of this proceeding, which will have its appropriate place further on, we remark that, from what was shown in the working and effect of the screw-propeller of the *Archimedes*, captain Richard Burridge, R.N., had expressed, in a letter addressed to the "Directors of the ship propeller company," in December 1839, his hope of its being fitted to an Atlantic steamer. In the following May, when the Board of Admiralty sent captain Chappell and Mr. Lloyd to examine into and report upon the merits of this screw, as compared with the ordinary paddle-wheels applied to her Majesty's mail-packets on the Dover station, those merits were brought more successfully before the attention of scientific and nautical men, and were the subject of a host of testimonials. Amongst the admirers of the screw-propeller was captain Claxton, the managing director of the Great Western steam-ship company. The interest which it possessed at the point of time when that company was building the largest ship in the world, led the directors to request their eminent consulting engineer, Mr. Brunel, to consider the subject of the screw-propeller, with the view to its being applied to the *Great Britain*. The observations and experiments which he accordingly made, and the consideration which he devoted to it, convinced him, against his prepossessions, that the screw-propeller was superior to paddle-wheels, on several grounds; and that the whole question, fairly looked at, showed that it was desirable to employ this sort of propeller instead of paddle-wheels in that ship. Acting on the advice which Mr. Brunel gave, the directors resolved, in December 1840, to adapt the ship to the screw; and all the arrangements were from that time made with the view to this object. The same boldness of enterprise, and the same confident reliance on deductions from facts ascertained on a small scale, are observable in the resolution to employ the screw, that were shown in the determination to use iron as the material of the hull; and the result has in each case vindicated a procedure grounded upon facts of so circumscribed experience, that the directors seem to have been the objects of but little sympathy before the performance of the vessel, with the screw, proved the soundness of the reasoning on which it had been adopted.

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* Letter from " E.," in the 'Civil Engineer and Architect's Journal,' January 1841.

The *Great Britain* was launched on the 19th of July 1843. The machinery was constructed on the works of the company, as no engineer seemed willing to undertake the task under a contract. The result of fitting the engines into the ship at the works was, that thus she was too much deepened to pass out of the dock, until some alteration was made, causing a detention of a few months. This having been made, the *Great Britain* was released, and made her first experimental trip on the 12th of

December 1844, the conduct and result of which were stated in a letter from Mr. Guppy, the company's engineer, to the directors, dated the 17th of December. "The engines commenced working at six to eight revolutions per minute, and this speed was gradually increased to twelve to thirteen revolutions. The velocity acquired by the vessel during this time was exactly that which had been intended, being at the rate of one knot per hour for every one-and-a-half revolution of the engines per minute—thus twelve revolutions gave exactly eight knots. In this manner, the ship proceeded to the Holms, where some evolutions were performed, with the view of trying how she steered, and it was ascertained that she was very completely under the command of the helm. On the return to Kingroad, the speed was increased to rather more than sixteen revolutions per minute, when her rate of going was ascertained to be eleven knots. At this time the velocity of the screw through the water was 1218¾ per minute.
Eleven knots are 1115½

Leaving only 103¼ feet for the slip of the screw. In other words, for 1000 miles that the screw shall advance through the water, the progress of the ship will be 915 miles. For the purpose of comparison, I have referred to Mr. Brunel's report, wherein I find that on the best average voyages of the *Great Western*, for 1000 miles that her paddle-wheels should advance, she progresses only 787: and with these experiments with the *Archimedes*, on which he founded his report, while her screw should have advanced 1000, she actually only progresses 775 miles."

The *Great Britain's* career was short; it had, nevertheless, the immediate advantage of reducing the fares across the Atlantic, considerably, owing to the *relatively* smaller expense of working so large a ship. And the unfortunate event which stopped her course of service, has supplied another proof of the excellence of iron as a material for ship-building.

Soon after the Atlantic ocean began to be navigated regularly by steam-vessels, the importance of a better means of communication between England and the West Indies led to the formation of a very respectable and influential company for the accomplishment of that object. The "Royal Mail Steam Packet Company" having, therefore, built a sufficient number of large steam-vessels, suited to the character of the service, in 1841, entered into a contract with the Board of Admiralty, in December of that year, for the conveyance of the post-office mails between England, the West Indies, and the gulf of Mexico, by the employment of not less than fourteen steam-vessels, ten of which should be of 400-horse power, or more, and the other four of at least 250-horse power, for inter-colonial service. This service has, therefore, been executed by the regular departure from England of two packets in each month. The contract price for this is £240,000 a year. The general character and regular performances of the vessels belonging to this company, as well as of those belonging to the Peninsular and Oriental company, Mr. Cunard's and other packets, have established and maintained the claim of steam-vessels to assured confidence in their fitness for any service that is likely to be required of packets on the ocean.

From the time when steam-packets began to be employed in the conveyance of foreign mails, those which conveyed them to the ports in the Peninsula, the Mediterranean, and the West Indies, started from and arrived at Falmouth, until September 1843; at that time, the arrangements were altered, and Southampton has ever since been their station.

When, sometime later, the "Pacific steam navigation company" was formed for the employment of steam-packets in the Pacific ocean, in addition to other efforts that were made in this country, and by foreign nations, to extend and amplify the advantages that steam navigation supplies, which are not necessary to be particularized here, there were few obvious wants that such accommodation would supply, remaining unregarded by the various companies formed for this purpose.

We need not extend these remarks further, to show how rapidly steam-navigation has enlarged the sphere of its operations to all parts of the world, developing at the same time the magnitude of its importance. Perhaps no power of physical effort under the control of man has ever, within so short a space of time, produced results contributing in such variety of ways, and to so great an extent, to the comfort and convenience of civilized nations generally, as that of steam has. And, as a means of conveyance, it has surpassed every other, in the comforts, and regularity, and despatch, which travellers have ever had at their command; and which, whilst it has diminished the inconveniences, has diminished also the expense; and has rendered far more easy, and, in many cases given a practicability to the social communications by which the best feelings of society are cherished.

The ingenuity which has been engaged concurrently with commercial enterprise, has, from the early stage of steam navigation to the present time, gone along with the obvious wants of the public, in adapting the capabilities of steam-vessels to acknowledged necessities; and, if in some periods of its brief history, it has not fully kept pace with them, it has speedily endeavoured to make amends for past deficiency by labouring to overtake those wants. The following lists of steam-vessels, with the dimensions, power, and other particulars of detail, will show very much of the character of commercial steam navigation when it was adapted only to rivers,—as it improved under successive changes,—and in the fully-expanded excellence in which it is well known at the present time, on some of the most important lines of traffic. The sections, which are given in the plates, still further show how change has accompanied experience, generally resulting directly in improvement, or leading indirectly to it.

STEAM-PACKETS BELONGING TO THE ROYAL WEST INDIA MAIL PACKET COMPANY.

NAMES.	When Built.	Builders.	Engineers.	Length.	Breadth.	Depth in Hold.	Burthen in Tons, Custom-house Admeasurement.	Cargo carried.	Mean draught of Water.	Average Speed.	Length and Distance of Voyages.		Consumption of Fuel in one Day.	Power of Engines.	Diameter of Cylinder.	Length of Stroke.	Diameter of Paddle-wheels.
				feet.	ft. in.	ft. in.			ft. in.	knots fath.	days.	miles	tons.		ins.	ft. in.	ft. in.
Thames	1841	Pitcher, Northfleet	Maudslay, Sons, and Field	212	33 0	31 1½	1676	When complete with Coals, the average room for Cargo is about 70 Tons.	—	7 6	126 187	15660 22191	25½	450	74¾	7 0	17 0
Medway	1841	Ditto	Ditto	212	33 4	30 6	1666		17 6	7 5	108 96	13650 11936	26	450	—	—	—
Trent	1841	Ditto	Miller & Ravenhill	212	33 4	30 6	1666		17 0	7 2	95 132	13200 15600	25	430	74	7 0	29 0
Avon	1842	Paterson, Bristol	Acraman	215	33 5	30 1	1880		17 6	7 6	81 113	11622 13270	24½	450	75	7 0	30 8
Severn	1842	Ditto	Ditto	215	33 5	30 1	1886		17 6	8 0	106 144	13650 17932	28	450	75	7 0	30 0
Clyde	1841	Duncan, Greenock	Caird and Co.	213	34 5	30 9	1841		12 6	7 3	126 109	14991 13650	26	450	74½	7 6	30 6
Tay	1841	Wood, Dumbarton	Ditto	214.5	33 5	30 8	1858		17 6	7 5½	79 46	11622 7248	27	450	74½	7 6	30 0
Teviot	1841	Duncan, Greenock	Ditto	212	33 7	30 6	1744		—	7 3	108 88	13650 11622	26	450	74½	7 6	—
Forth	1841	Menzies, Leith	Bury and Co.	213	33 6	30 3	1311		17 6	7 2	108 96	13650 11936	26	450	—	—	—
Dee	1841	Scott & Sons, Greenock	Scott & Sinclair	213.9	30 4	30 0	1848		17 6	7 2	83 109	11622 13650	25½	450	73	7 0	28 6
Great Western	1837	Paterson, Bristol	Maudslay, Sons, and Field	207.1	31 8	23 1	1778		16 0	7 7	199 94	23646 11936	26½	440	73½	7 0	28 3
Conway	1847	Pitcher, Northfleet		190.5	31 4	26 7	Builders' Measurement, 895[illegible]		—	8 0	7 11	1054 1342	22	270	—	—	—

TRANSATLANTIC STEAM PACKETS.

NAMES.	When built.	Builders.	Engineer.	Length. Between the Perpendiculars	Length. Of Keel for Tonnage.	Breadth. Extreme.	Breadth. Moulded.	Depth in Hold.	Burthen in Tons. Old Measurement.	Burthen in Tons. New Measurement.	Horse-power of Engines.	Speed in Knots per hour.
				ft. ins.	ft. ins.	ft. in.	ft. in.	ft. in.				
Caledonia.	1840	C. Wood . .	Napier	204 6	184 2½	33 10	33 2	22 4	1121	1138	440	8.5
Hibernia .	1842	R. Steele & Co.	Ditto	219 8	198 2	35 10	35 0	24 2	1353	1421	500	9.5
Niagara .	1847	Ditto	Ditto	251 5	228 5½	38 3	37 4	25 9	1774	1824	650	11.0

STEAM VESSELS WITH BOULTON AND WATT'S ENGINES.

Names.	Lines of Service.	When Built.	Builders.	Engineers.	Length.	Breadth.	Depth in Hold.	Burthen in Tons.	Mean Draught of Water.	Horse Power of Engines.	Length of Stroke.	Diameter of Cylinders.	Diameter of Paddle-wheels.
					ft. in.	ft. in.	ft. in.		ft. in.		ft. in	in.	ft. in.
Caledonia .	Glasgow & Greenock	1815	Wood .	Boulton and Watt.	94 0	27 8	9 0	95	4 3	28	2 6	23	13 0
Sons of Commerce	London & Gravesend	1816	Evans .		85 0	25 3	8 1	77	3 5½	20	2 6	26¾	10 0
Favorite .	London & Margate .	1818	Evans .		90 0	33 0	9 2	121	—	40	2 6	26¾	13 4
Venus . .	London & Margate .	1820	Evans .		111 0	41 0	11 3	269	4 8	60	3 0	31½	16 0
Arrow . .	Dover & Calais . .	1821	Evans .		92 2	33 0	10 3	130	5 11	40	2 6	26¾	10 0
Meteor .	Holyhead & Howth .	1821	Evans .		103 0	37 0	11 6	188	7 2	60	2 0	31½	12 0
Cinderella.	Holyhead & Howth .	1823	Wigram		116 6	37 10	12 6	234	8 9	80	3 6	35½	13 2
Soho . .	London & Leith . .	1823	Wigram		151 3	46 0	17 5	510	10 1	120	4 0	42	15 8
Hawk . .	Gravesend . .	1825	Wallis .		93 6	31 9	9 6	133	5 2	40	2 6	26¾	11 0
Dart . .	London & Margate .	1825	Evans .		115 0	40 3	12 3	262	5 10	100	3 6	39½	14 0
Magnet .	London & Margate .	1827	Tibbut .		126 0	44 6	12 6	313	6 3	120	4 0	42	15 6
Dragon .	Holyhead & Howth .	1827	Harwick		117 4	38 0	12 6	237	7 9	80	3 6	35½	13 6

STATISTICAL DATA OF SEVERAL OF THE LONDON AND GRAVESEND STEAM PACKETS.

Names.	When Built.	Builder.	Engineer.	Length	Breadth.	Depth in Hold.	Burthen in Tons.	Mean Draught of Water	Area of Midship Section.	Displacement in Tons.	Speed of the Wheels in Knots per Hour.	Speed of the Vessel in Knots per Hour.	Slip per cent. of the Wheel.	Displacement divided by the Speed.	Area of Midship Section divided by the Speed.	Horse Power of Engine.	No. of Strokes of the Engine per Minute.	Diameter of the Cylinder.	Length of Stroke.	Diameter of Paddle-wheels.
				ft.	ft in	ft in		f in	sq ft									in.	f in	ft in
Father Thames	1840	Ditchburn	Penn & Son .	140	19 0	10 0	247	4 0	50.0	115.0	17.4	12.95	27.1	8.9	3.8	75	34.9	35	3 6	18 6
Railway .	1842	Ditchburn	Penn & Son .	145	19 1	9 10	258	5 3	52.5	118.8	16.55	12.02	27.7	9.9	4.3	90	32.4	39½	3 0	15 6
Brunswick .	1842	Ditchburn	Seaward	145	19 1	9 10	258	5 3	52.5	118.8	16.5	11.53	30.2	10.2	4.5	90	31.3	39½	3 0	15 6
Ruby . . .	1836	Wallis .	Seaward	155	19 0	10 2	272	4 6	61.8	170.0	17.0	13.17	23.4	12.9	4.6	100	31.2	40	3 6	17 6
Vesper . .	1836	Fletcher .	Miller .	153	18 0	10 6	250	5 0	51.4	138.3	17.0	11.78	32.0	11.7	4.3	90	36.2	—	—	15 0
Meteor . .	1844	Miller .	Miller .	170	18 0	—	—	4 0	48.0	124.8	17.9	12.68	32.0	9.8	3.7	80	34.0	37	3 0	15 9

IRON STEAM-VESSELS BUILT BY MESSRS. TOD AND McGREGOR FOR DIFFERENT SERVICES.

Names.	Line of Service.	When built.	Builders.	Engineers.	Length.	Breadth.	Depth in Hold.	Length of Engine-room.	Tonnage exclusive of Engine-room.	Tonnage including Engine-room.	Horse-power of Engine.	Diameter of Cylinder.	Length of Stroke.	Diameter of Paddle-wheels.
					feet.	feet.	feet.	feet.				ins.	feet.	feet.
Princess Royal	Glasgow & Liverpool	1841	Tod and McGregor.	Tod and McGregor.	194.6	26.8	16.8	61.5	416.9	746.6	400	73	6.3	28
Defiance	Tug on the Clyde........	,,			112.3	20.3	11.7	54.5	79.7	219.8	—	—	—	15
Prince of Wales	Belfast & Ardrossan	,,			159.6	24.6	13.5	—	312.9	500	250	61	5.0	24
Prince of Cork.	Cork, &c.	1843			130.9	17.7	7.9	35.0	97.2	150.2	65	48	3.6	16
Emperor	Glasgow & Helensburgh.	,,			121.7	16.1	7.2	37.4	62.1	109	50	41	3.6	14.6
Princess Alice..	Belfast & Fleetwood	,,			164.7	23.3	13.9	50.6	259	436.5	200	50	5.0	20
Invincible	Glasgow and Milport	,,			130.1	16.8	8.0	35.9	78.5	130.7	75	50	4.0	17
Her Majesty...	Ardrossan & Fleetwood..	1844			178.1	25.2	15.2	54.2	296.4	520.9	300	65	5.6	26.6
Royal Consort.	Ardrossan & Fleetwood..	,,			177.9	25.2	15.2	54.2	297	521.9	300	65	5.6	26.6
Albion	Glasgow & Belfast	,,			145	21.3	10.6	51.6	157	281.7	160	47	5.0	20
Windsor Castle	Glasgow & Rothesay	1845			174.4	17.7	9.2	56.3	101.8	201	110	60	4.0	19
Sea King......	Belfast & Liverpool......	,,			182.4	25.3	15.8	58	390.4	644.8	380	69	6.0	28
Scotia	Ayr & Stranraer	,,			141.3	17.5	8.7	50.2	81.6	164.8	95	54	4.0	17
Sovereign	Glasgow & Helensburgh.	,,			138.8	16.5	8.2	40.1	76.29	135	75	50	4.0	17
Dunrobin Castle	Glasgow & Inverary	,,			162.0	19.0	8.9	47.5	120	206.8	110	60	4.0	19
Prince of Wales	Liverpool & Bangor	1846			174.1	21.6	11.4	59.9	210.8	346.5	150	65	5.0	22
Mary Jane	Glasgow & Stornoway ..	,,			149.5	19.3	9.9	43.5	125.2	211.3	100	57	4.6	18
Countess of Galloway..	Liverpool & Garlieston ..	,,			165.5	24.4	14.3	46.6	316.4	492.4	290	54	5.0	22
Briton	Ayr & Stranraer	1847			144.8	19.4	9.2	32.4	151.8	214.4	100	56	4.6	18
Royal Alice....	Cork, &c.	,,			145.4	18.4	8.0	37.6	104.6	164.5	80	52	4.0	17.6
Cumberland...	Liverpool & Carlisle	,,			197	24.2	13.4	49.2	346.9	518	290	64	5.0	24
Trafalgar	Liverpool & Dublin.	,,			189.7	27.2	16.7	56.8	493.2	772.5	370	69	5.6	26
Blenheim......	Belfast & Liverpool	1848			206.5	25.0	13.9	67	399	651.3	400	—	—	28

STEAM PACKETS EMPLOYED IN VARIOUS SERVICES.

Names.	When Built.	Builders.	Engineers.	Length.		Breadth.		Depth in Hold.		Burthen in Tons.	Mean Draught of Water.		Horse Power of Engine.	Diameter of Paddle-wheels.	
				ft.	in.	ft.	in.	ft.	in.		ft.	in.		ft.	in
Mongibello . .	1840	Pitcher	Maudslay, Sons, and Field.	156	0	26	6	16	6	511	10	6	200	19	6
Thames . . .	1840	Pitcher		210	0	36	0	30	4	1300	16	0	400	28	0
Hecla . . .	1841	Curling and Young .		170	0	28	6	16	7	660	11	6	200	18	0
Rugiero . . .	1841	——		190	0	34	0	19	2	1023	13	0	300	22	0
Crimea . . .	1842	Pitcher . . .		175	0	31	10	20	0	823	12	9	260	22	6
Princess Alice . .	1843	Ditchburn and Mare .		140	0	20	0	11	0	274	6	3	120	18	5
Stromboli . .	1844	Pitcher . . .		165	0	27	9	16	6	604	11	10	220	20	0
Princess Maude . .	1844	Ditchburn and Mare .		143	0	20	6	10	3	294	6	3	120	19	4
Queen of the French .	1844	Ditchburn and Mare .		158	0	21	0	11	0	341	6	3	120	19	0
Il Giglio . . .	1845	——		124	0	18	0	10	9	—	6	3	60	14	8
Lowestoff . .	1846	Ditchburn and Mare .		96	0	17	0	9	0	131	5	6	60	12	0
Belgian Railway . .	1846	Ditchburn and Mare .		140	0	21	0	10	3	298	6	6	120	18	9
Vesuvio Capri . .	1846	Ditchburn and Mare .		180	0	26	0	15	0	591	9	6	220	23	10
Erin . . .	1846	Ditchburn and Mare .		200	6	28	8	18	0	803	10	5	280	22	10
Express . . .	1847	Ditchburn and Mare .		160	0	22	1	11	0	377	6	6	160	18	0
Courier Despatch .	1847	Ditchburn and Mare .		170	0	23	0	11	8	437	6	6	200	19	0
Scotia	1847	Wigram . .		195	0	27	6	14	0	700	8	6	400	24	8
Anglia . . .	1847	Ditchburn and Mare .		190	0	26	9	14	9	662	8	6	350	24	8

STEAM VESSELS EMPLOYED IN VARIOUS SERVICES.

NAMES.	Line of Service.	When built.	Builders.	Engineers.	Length.	Breadth.	Depth in Hold.	Burthen in Tons, Custom-house Measurement.	Cargo carried.	Draught of Water. Forward.		Aft.		Area of Midship Section.	Displacement in Tons.	Average Speed.	Length and Distance of Voyage. Hours.	Knots.	Horse-power of Engines.	Diameter of Cylinder.	Length of Stroke.		How Propelled.	Diameter of Propeller.	
					feet.	feet.	feet.		tons	ft.	in.	ft.	in.	sq. ft.		knots.				ins.	ft.	in.		ft.	in.
Dundee	Dundee to London	1834	J. Wood	R. Napier	160.7	25.7	17.6	638.4	420	13	0	14	0	372	1050	9.05	44.2	400	265	58	5	6	paddles	24	0
Perth	do. do.	1834	,,	,,	160.7	25.7	17.6	638.4	420	13	0	14	0	372	1050	8.97	44.6	400	265	58	5	6		24	0
London	do. do.	1836	,,	,,	167	25.7	18.0	686.9	440	13	0	14	0	—	—	8.97	44.6	400	305	62	5	9		24	6
Fire King	Glasgow to Liverpool..	1838	Thomson	,,	175	24.9	14.7	563	150	10	6	10	6	237	—	11.9	16.5	196	255	57	5	6	,,	22	0
Vanguard	Glasgow to Dublin	1843	R. Napier	,,	182.9	26.3	16.4	—	200	11	6	12	0	274	966	10.5	17.2	180	330	65	5	10	,,	27	0
City of London ..	Aberdeen to London ..	1844	,,	,,	216.8	30.0	19.2	1116	460	13	6	14	2	374	1608	10.5	43.7	450	405	70¾	6	6	,,	28	2
Dundalk	Dundalk to Liverpool..	1844	,,	,,	171.3	25.1	15.2	601	280	10	6	11	6	247	990	10.5	12.3	130	295	61½	5	6	,,	24	9
Ben-my Chree....	Douglas to Liverpool ..	1845	,,	,,	151.9	20.3	12.5	295	100	7	9	8	4	—	—	10.5	7.0	75	140	44½	4	0	,,	19	6
Thetis	Glasgow to Belfast	1845	,,	,,	190.5	22.4	11.5	345	100	7	9	8	3	152	455	12.1	7.7	94	160	65	5	0	,,	22	0
Brian Boroihme ..	Drogheda to Liverpool.	1846	,,	,,	180.0	25.9	16.5	649	230	11	0	11	6	247	915	11.6	11.0	128	320	64	5	6	,,	26	8
Viceroy	Glasgow to Dublin	1846	,,	,,	197.7	26.2	17.5	791	200	10	9	11	3	260	960	12.0	15.0	180	370	68	6	0	,,	26	8
Tynwald	Belfast to Liverpool ..	1846	,,	,,	188.0	25.7	15.8	611	250	10	3	10	8	245	—	11.75	13.6	160	280	60	5	6	,,	23	8
Duke of Sutherland	Aberdeen to London ..	1847	,,	,,	197.9	27.2	17.5	803	280	12	9	13	6	314	1167	10.0	45	450	375	68½	6	0	,,	25	0
Earl of Aberdeen..	do. do.	1847	,,	,,	207.9	27.0	17.8	907	340	13	3	14	0	332	1310	10.25	44.7	450	395	70½	6	0	,,	25	10
Pride of Erin....	Dundalk to Liverpool..	1847	,,	,,	194.8	26.2	15.7	762	300	11	0	11	6	272	—	11.5	11.3	130	390	70½	5	6	,,	25	6
Thistle..........	Glasgow to Londonderry	1848	,,	,,	198.4	26.3	16.0	653	200	10	8	11	4	273	972	12.2	10.0	122	360	68	5	6	,,	25	8
Celt	Glasgow to Campbelton	1848	Denny Brs.	Wingate	155.9	20.3	10.3	272	90	6	6	7	6	128	333	11.75	6.2	74	150	62	5	0	,,	20	0
Fire Queen	Glasgow to Ayr	1844	R. Napier	R. Napier	132.4	18.0	9.2	134	60	6	3	8	6	104	225	11.5	5.0	57	110	36	3	0	screw	5	4
Northman	Leith to Kirkwall	1847	Denny	Caird&Co.	100.0	20.65	12.1	185	150	10	0	11	0	190	350	7.1	30	216	55	24	1	9		7	0
Secret	Liverpool to the Levant	1847	,,	,,	133.0	22.0	13.0	310	300	11	0	12	0	233	594	7.8	191	1490	75	28	2	0		8	0
Falcon	Halifax to Bermuda ...	1848	R. Steele	,,	124.6	24.6	14.0	286	150	10	3	12	10	194	459	8.0	96	750	120	36	2	0	,,	9	0
Chevy Chase	Newcastle to Hamburg	1849	Denny	,,	156.1	22.8	13.0	371	380	11	0	12	0	233	694	8.25	36.5	300	125	36	2	3	,,	10	0

STEAM VESSELS BELONGING TO THE PENINSULAR AND ORIENTAL STEAM NAVIGATION COMPANY.																				
Names.	Materials.	Line of Service.	When Built.	Builders.	Engineers.	Length.	Breadth.	Depth.	Burthen in Tons.	Mean Draught of Water.		Coal Space.	Cargo Space.	Horse Power of Engines.	Length of Stroke.		Diameter of Cylinder.	Diameter of Paddle-wheels.	Description of Engines.
						ft.	ft.	ft.		ft.	in	tons	tons		ft.	in.	ins	ft.	
Hindostan .	Wood	England, Gibraltar, Malta, and Alexandria.	1842	J. Wilson .	Fawcett and Co. .	217.6	35.8	30.1	1652	16	10	550	200	520	8	0	78	32	Side Lever
Oriental . .	,,		1840	J. Wilson . .	Fawcett and Co. .	220.0	33.5	28.5	1476	16	0	450	350	420	7	0	73	27½	,,
Achilles . .	,,		—	R. Steel .	Caird and Co. .	205.9	27.0	21.0	853	12	9	280	300	420	7	0	74	30	,,
Tagus . . .	,,		1837	J. Scott and Sons .	Scott, Sinclair, and Co.	182.1	26.0	17.4	709	14	6	265	300	286	5	9	62	23½	,,
Indus . .	Iron		1847	M. and H. L. Wigram .	Miller, Ravenhill, & Co.	208.0	33.9	21.2	1251	16	6	450	300	450	7	0	75	28¼	Oscillating
Sultan . .	,,		1847	Tod and McGregor	Tod and McGregor .	224.2	29.1	17.8	990	14	0	320	500	400	6	6	73	28½	Direct act.
Ripon . .	,,		1846	M. and H. L. Wigram .	Miller, Ravenhill, & Co.	231.3	33.9	21.1	1394	16	0	430	300	450	7	0	75	28¼	Oscillating
Ariel . . .	,,		1846	Ditchburn and Mare	J. Penn and Sons .	194.0	28.4	16.0	821	—		220	250	300	5	9	65	26	,,
Erin . . .	,,		1846	Ditchburn and Mare	Maudslay and Co. .	199.0	27.6	17.2	810	14	6	220	350	280	5	0	45	22½	Double cyl.
Montrose .	Wood	England, Gibraltar, Cadiz, and Lisbon.	—	J. Scott and Sons	Scott, Sinclair, and Co.	166.0	23.6	16.8	536	10	6	180	250	240	5	6	58	22½	Side Lever
Iberia . .	,,		1836	Curling and Young	Miller, Ravenhill, & Co.	155.4	21.2	15.7	520	12	6	150	290	190	4	6	51	19	,,
Jupiter . . .	,,		—	J. Scott and Sons	Scott, Sinclair, and Co.	158.2	25.0	15.9	439	12	3	150	160	210	5	0	54	20.9	,,
Pacha . .	Iron		1843	Tod and McGregor	Tod and McGregor .	160.0	26.5	15.6	517	11	0	165	200	210	5	0	54	24	,,
Madrid . . .	,,		1845	Miller, Ravenhill, & Co.	Miller, Ravenhill, & Co.	163.0	23.5	15.2	446	10	3	120	150	140	3	9	46	17	,,
Bentinck .	Wood	East India and China.	1843	J. Wilson .	Fawcett and Co. .	217.1	36.0	30.4	1702	—		550	200	520	8	0	78	32	,,
Precursor . .	,,		1841	J. Wood . .	R. Napier . .	229.0	33.5	24.4	1640	18	0	550	200	460	7	0	80	30	,,
Braganza . .	,,		1836	Fletcher and Co.	Scott, Sinclair, and Co.	188.5	24.8	18.6	707	13	11	180	200	264	5	6	62	24	,,
Lady Mary Wood	,,		1842	J. Wilson . .	Fawcett and Co. .	160.8	25.5	16.1	503	—		170	200	260	5	6	60	22¼	,,
Haddington . .	Iron		1846	T. Vernon and Co.	Bury and Co. .	217.3	33.3	29.6	1303	17	0	450	300	450	6	10	76	29½	Direct act.
Pottinger . .	,,		1846	W. Fairbairn and Sons .	Miller, Ravenhill, & Co.	205.3	34.0	21.7	1225	17	6	450	300	450	7	0	75	28½	Oscillating
Pekin . . .	,,		1847	Tod and McGregor	Tod and McGregor .	214.7	29.7	18.6	1000	14	0	320	450	400	6	6	73	28¼	Direct act.

STEAM VESSELS BELONGING TO THE EAST INDIA COMPANY.

Names.	When Built.	Whose Design.		Length.		Breadth.		Depth in Hold.		Burthen in Tons.	Mean Draught of Water.		Area of Mid-ship Section.	Displacement in Tons.	Horse Power of Engines.	Diameter of Paddle-wheels.	
		Vessel.	Engines.														
				ft.	in.	ft.	in.	ft.	in.		ft.	in.	sq ft			ft.	in.
Nicholai I.	1839	Ritherden and Carr.	Seaward	185	0	29	0	17	6	—	12	0	278	1017	—	24	10
Cleopatra	1839		Maudslay & Co.	178	5	31	0	19	0	770	14	6	356	1317	220	22	0
Queen	1839		Seaward	177	10	31	0	19	0	760	14	9	359	1249	220	22	0
Sesostris	1839		Maudslay & Co.	184	9	32	6	19	6	876	14	6	366	1361	220	22	0
Memnon	1841		Maudslay & Co.	206	5	34	0	21	6	1143	14	6	406	1733	420		
Acbar	1841		Napier	206	5	34	0	21	6	1143	14	6	406	1733	420		
Peiki Tigârét	1843		Miller & Ravenhill	168	0	26	6	16	6	568	12	0	256	862	190	19	6
Imperador	1842		Miller & Ravenhill	151	0	24	0	14	0	418	10	0	206	611	140	15	3
Imperatrix	1842		Miller & Ravenhill	151	0	24	0	14	0	418	10	0	206	611	140	15	3
Moozuffer	1845		Seaward	220	0	37	0	23	0	1440	16	0	488	2301	500	29	0
Agdaha	1845		Scott, Sinclair, & Co.	220	0	37	0	23	0	1440	16	0	488	2301	500	29	0
Fire Queen	1843		—	159	7	26	4	15	0	500	10	0	235	701	—	21	9

The preceding Tables show, with more precision than could otherwise be shown, the gradual and continuous enlargement of steam-vessels, to meet the growing wants for which they were provided. At the same time, they are intended to serve for reference to constructors, in determining some of the principal elements of the body. It was considered desirable to include some other elements which affect their speed and general good qualities; but this was not found to be practicable to such an extent as would supply data for general comparison. And even if the required elements could have been more fully obtained, and the performances of the respective vessels, with reference to their construction, were yet unknown,—we must have regarded the vessels, as to the elements in question, as undetermined experiments. So far as the principal elements could be obtained, the Tables contain no inconsiderable number of the best steam ships and vessels that have been built in private service. For the information they contain, the author is indebted to the kindness of Captain Chappell, R.N., of the Royal West India Mail Packet Company, Captain Claxton, R.N., late of the Great Western Steam-ship Company, the Directors of the Peninsular and Oriental Steam-ship Company, Mr. Brown, of the firm of Boulton and Watt, Mr. Robert Napier, Mr. Ritherdon, Mr. Field, and other gentlemen.

We have regarded steam navigation, its progress and its importance, not only nationally but universally, in commerce.

The next aspect under which it is to be viewed is more limited, and yet it is deeply important as a national object: it is its use in war. The geographical character of Great Britain, which has always magnified the importance of her navy, now shows how dependent the nation must be on an efficient coast-guard of armed steamers, in the event of another European naval war. Foreign preparations are a warning of this necessity; and, indeed, the whole plan of naval warfare is likely to be so materially changed by means of steam-vessels, that it is evidently necessary to have steam-ships capable of undertaking, or of aiding in, every class of its operations.

Officers of great talent and experience have given currency to ideas as to the required conditions of steam-vessels for the several classes of naval service in contemplation, and steamers have been built with some reference to the particular services in which it is supposed they will be required; it is, however, doubtful whether any steam navy, that would be of much use to this country in war, must not be materially different in its character from the vessels of which the bulk of the present steam navy consists. Several considerations demand a great change: the machinery ought to be depressed below the level of common danger from shot; and economy requires that steam-vessels employed in war should be perfect sailing-vessels in every respect, as well in the *position* as in the *power* of sail. The conditions proper to their sailing qualifications should be determined *first;* and the disposition of the machinery should follow in secondary order, as it is certain that the best adjustment of the sails and of the machinery may be made in the same ship.

The great change which it appears will be necessary to the competency of a steam navy is that of substituting the screw propeller for paddle-wheels, in armed steam-vessels; using this, however, as an auxiliary power, being, independently of this, perfect sailing vessels. When one considers the general uses of vessels engaged in war, it is hardly possible to regard those which have only bow and stern guns as being anything more than auxiliary vessels. These are, however, almost all that steam-vessels generally propelled by means of paddle-wheels are adapted to use. It is proved to be practicable to place the machinery, boilers and steam-chest, below the water-line in large steamers, and so one of the greatest dangers is obviated; but still the shaft and connecting gear, as well as the paddle-wheels, are liable to be damaged by shot, particularly in broad-side exposure. There is not the same facility of protecting the machinery of small paddle-wheel steamers. The vertical cylinders, as well as the boilers, require a depth beyond what the hold of small vessels will allow, and they are unavoidably exposed. Injury to the machinery would take away the one grand feature of superiority, and reduce the paddle-wheel steam-vessel below the qualifications of a sailing-vessel. Until the conditions of naval steamers can be so determined that there is a reasonable probability of their sustaining such engagements as they are intended to go into, without the imminent hazard of being immediately disabled, dependence on them in warlike operations generally, must be extremely precarious. These conditions are practicable —with the screw-propeller.

The late board of Admiralty contemplated an improvement in the character of naval steamers, in ordering the *Odin* to be built capable of carrying broadside armament on the main-deck; that object was accomplished, subject, nevertheless, to the too-elevated position of the machinery. Sir Charles Napier sought to avoid this danger in the *Sidon*. His success has realised only a part of the qualifications for warlike service that are attainable.

There have been few facts connected with the steam navy more generally and more forcibly claiming attention, than the small amount of armament relatively to the burthen of the vessels and horse-power of the machinery. This was not a defect necessarily connected with the earliest efforts made in this direction; it has been a fact associated with the line of efforts down to the present time; and where a better disposition has been made, there we see the exceptions. Two or three facts may suffice for illustration. In 1843 the *Retribution* was built of 1641 tons, having machinery of 800 horse-power; but her weight of metal thrown was only 472 pounds. Further, the quantity of sail carried has been very small in relation to the dimensions of the ships; so that, generally, the power of sail in war steamers has been merely auxiliary, and hence the constant expenditure of coals for almost all purposes of locomotion, as if there had been no such thing as wind. The quantity of sail carried by the *Retribution* is 17,192 square feet: a perfect sailing ship, of the same tonnage, would have 23,000 square feet. The error of making steam the principal power rather than that of wind on the sails, has been making the cost of coals for such a ship about fifty pounds sterling per day of twenty-four hours. This excessive expenditure has been lately restrained by the board of Admiralty, the use of steam being now sanctioned only when it is necessary to use it, through the want of wind, or on account of its being unfavourable. This general condition incident to naval steam-vessels shows the importance of making them complete sailing vessels.

The *Odin* of 1400 tons, with engines of 560 horse-power, is armed to throw 664 pounds of metal, and she carries 14,853 square feet of canvass: still it must be acknowledged that she is an imperfect sailing vessel. Great difficulty has been experienced in uniting in the same vessel the two qualifications—of sailing and steaming—in their fullest required degree. This difficulty was not overcome in the *Odin*; the position of the machinery had been so determined that the masts could not be fixed in their proper places; but it has since been surmounted in other ships; and both the quantity and position of sail are determined, upon the principles which are applied to determine the like conditions in sailing ships.

A steam navy fully fit for its purposes, can hardly be expected, without ensuring perfect safety to the machinery. Paddle-wheels exclude this; and it is now, therefore, important that these should give place to the screw-propeller. There are no insurmountable difficulties in uniting and using the power of sail and that of steam with the screw, as there are with paddle-wheels. The sooner, therefore, that these, and other considerations, lead to the abandonment of the use of paddle-wheels in all steam-vessels to be used in war on the ocean, and to the use of the screw propeller in their stead, the sooner will England have a steam navy worthy of the expectations which rest on such an object. Paddle-wheels may yet have their advantageous use in small steamers which are intended to penetrate into rivers and other shallow water.

On the earliest attention given by the board of Admiralty to the use of steam-vessels for any purposes in the navy, the following passages are quoted from sir John Barrow's Auto-biography, considering that no person had better means than he, of knowing not only the general naval events of his time, but also the grounds and objects of any new plans that were introduced.

" Lord Melville was ever anxious to patronize any project decidedly advantageous to the navy. In fact, it is to him that we owe the first introduction of the application of steam, as a locomotive power, to the ships of the navy. So early as the year 1815 he directed the Navy Board to cause a sloop to be built of the name of *Congo*, and to order a steam-engine suitable for her from Boulton and Watt, to be used as a trial in a ship of war. When ready, early in the following year, the engine was ordered to be sent to Plymouth, where it might be useful for pumping water. The *Congo* was ordered to be fitted up as a sailing vessel, to be commanded by Captain Tucker" (Captain James H. Tuckey) " on his intended expedition to explore the African river of that name.

" What objections may have occasioned this change I forget, but while this was going on the ingenious Brunel took up the question of steam-navigation; stated all the difficulties that occurred to him—one of which was the external fitting, or propelling apparatus—and he undertook to obviate this objection by a practical experiment. There had been a steam-vessel built a couple of years before, called the *Regent*, I believe by a private individual, and purchased as a packet to run from Margate to London. He says, ' On the 9th July, 1816, the *Regent* left Margate with a strong gale of wind blowing right a-head, and against a very strong tide. When out at sea the gale increased very much, and the sea broke over the vessel for several hours. The covering of the wheels was stove in; they, however, received no injury, though they were now and then overwhelmed. The steam-engine yielding gradually, and for a moment, to a greater power, was soon in action again.'

" Lord Melville, in reply to Mr. Brunel's encouraging letter, says, 'That the Board deem it unnecessary to enter, at present, into the consideration of the question, as to how far the power of the steam-engine may be made applicable to the general purposes of navigation; but as it would be attended with material advantage to his Majesty's service if it could be used for the purpose of towing ships of war out of harbour, in the Thames or Medway, and at Portsmouth and Plymouth, when they would be prevented from sailing by contrary winds, desire him to submit his ideas on that part of the subject, if it appears to him to be practicable.' To this Mr. Brunel answers, by recommending that, as this is a practical experiment, the *Regent* (laid up for the winter) should be employed under the direction of some competent person. The trial was made, and from this period may be dated the introduction of steam navigation into the English navy.

"Lord Melville was now so fully convinced of the great utility which the naval service would derive from the application of steam as a propelling power, that he ordered a small vessel to be built at Deptford, by Mr. Oliver Lang, to be called the *Comet*, of the burthen of 238 tons, and to have engines of eighty horse-power. She was built accordingly, and ready for sea in 1822; and this little ship has been usefully and constantly employed ever since, and no complaint made either of the hull, the engines, or the paddle-wheels; and she is at this moment always ready for service at the shortest notice." * She has, however, since been removed from the employment for which she was intended, and is now kept for particular service.

Although the *Comet* was the first steam-vessel built for the navy in either of the government dock-yards, yet she was not the first steamer brought into the service: the *Monkey* was the first of which I have any recollection, or find any record. She was built at Rotherhithe, about the year 1821, upon the plan of Mr. William Elias Evans. Her use in the navy was the same as that for which the *Comet* was built; and it does not seem that any other use was at that time contemplated. As this was the first naval steamer, so she is the oldest, as she remains a useful vessel at the present time. She was of 212 tons burthen, and was fitted with engines of 80 horse-power. The third naval steam-vessel was the *Sprightly*, built by Messrs. Wigram and Green, at Blackwall, in 1823. She was of the burthen of 234 tons, and had engines of 100 horse-power. This vessel was employed as a packet, and continued running between Holyhead and Dublin till 1848.† In 1824 the *Meteor* was built after another design by Mr. Lang: her tonnage was 296, and her engines were of 100 horse-power.

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* Pages 388—390.

† She has since been offered for sale; but not being disposed of, she is now a tender to the Port-admiral, at Portsmouth.

She was intended to be employed both in towing ships and in any other duties for which she might be required.

From this considerate and slow introduction of steam-vessels as an auxiliary in naval service, they became appreciated; and the next year, 1825, witnessed the building of four, after plans by three constructors:—the *African*, of 295 tons and 90 horse-power, by Sir Robert Seppings; the *Avon*, of 361 tons and 170 horse-power, by Mr. Graham; and the *Kite*, of 300 tons and 170 horse-power, and the *Lucifer*, of 387 tons and 180 horse-power, both by Messrs. Humble and Hurry. These vessels are still in the service. The *Alban*, of 405 tons and 100 horse-power, was built in 1826, on the plan of Sir Robert Seppings; and the *Shearwater*, of 343 tons and 160 horse-power, on that of Mr. Graham. These vessels likewise remain in the service. In 1827 five steam-vessels were built, the largest of which was the *Carron*, of 494 tons and 120 horse-power, constructed by Sir Robert Seppings; and the use of them in the government service was then assuming a more general character.

The importance of employing steam-vessels led now to the adoption of measures calculated to improve their character. The Admiralty desired to engage all the talent in the service with the view to this end, and invited the several master shipwrights to send in plans which they respectively deemed the best suited for steam-vessels. Mr. Roberts, of Devonport dock-yard, supplied the plan on which the *Rhadamanthus*, of 813 tons and 220 horse-power, was built; Mr. Lang, of Woolwich, supplied the lines on which the *Medea*, of 835 tons and 220 horse-power, was built; Mr. Seaton, of Sheerness, supplied those on which the *Salamander*, of 813 tons and 220 horse-power was built: at this time Sir Robert Seppings gave the design for the *Phœnix*, of 802 tons and 260 horse-power. This steam-vessel has been recently fitted with a screw-propeller. It is no disparagement of the talents of their respective constructors to say that these vessels shared in the imperfections which were almost necessary to a time when the conditions of excellence in steam-vessels were only in the course of development; at the same time it is fair and just to say, that they were all useful vessels, and they have been durable and permanent in their usefulness. The *Dee*, of 704 tons and 220 horse-power, and the *Fire-fly*, of 556 tons and 220 horse-power, were also built on lines supplied by Mr. Lang. He gave a proportion of 1 horse-power to 2·527 tons in the *Fire-fly*, 1 to 3·52 in the *Dee*, and 1 to 3·8 in the *Medea*; Sir Robert Seppings gave 1 horse-power to 3·08 tons; Mr. Roberts gave 1 horse-power to 3·7 tons; and Mr. Seaton gave 1 horse-power to 3·718 tons.

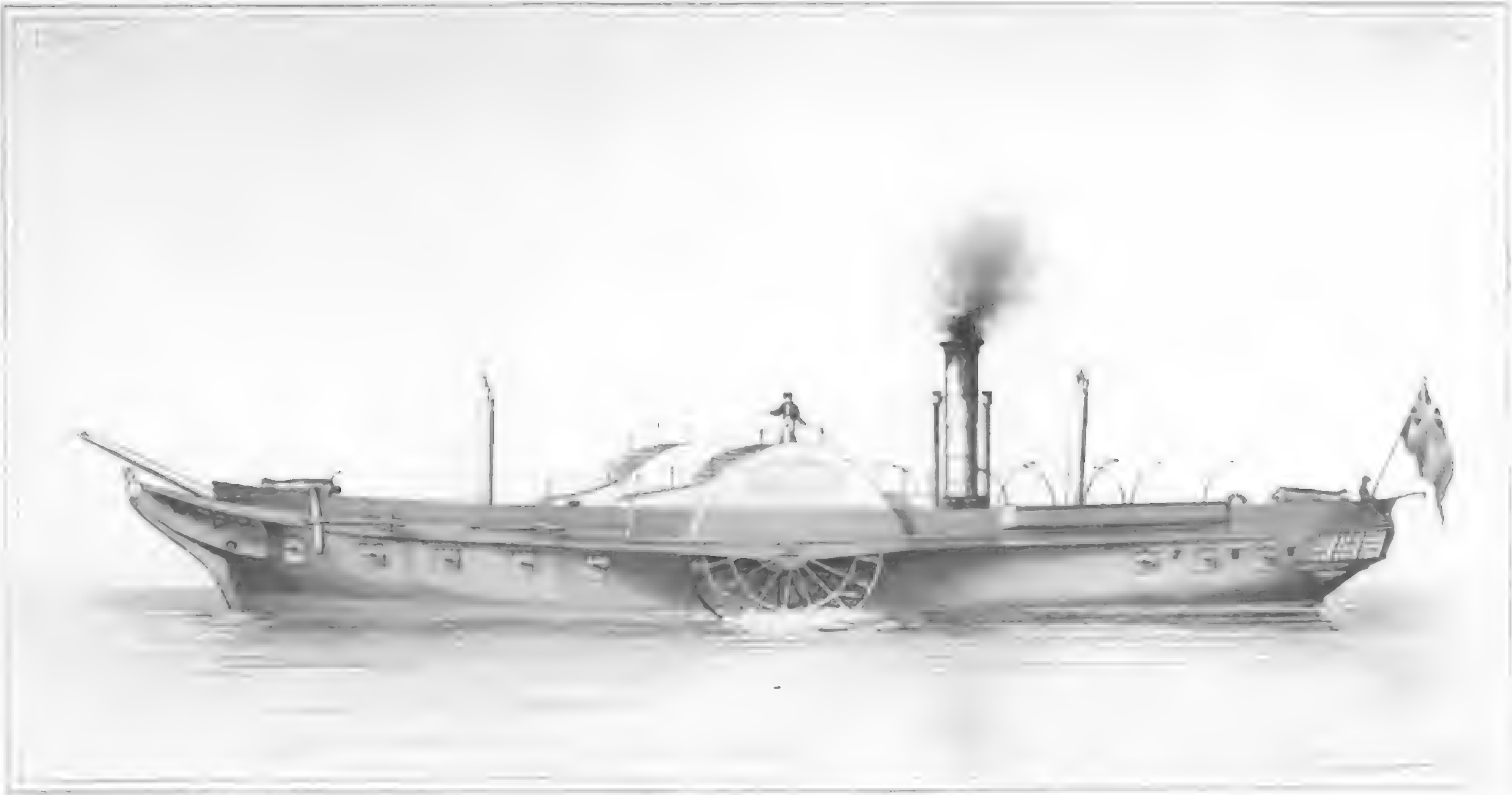
The *Columbia*, of 361 tons and 100 horse-power, constructed by Sir Robert Seppings, was built at Woolwich, in 1829. In that year were six steam-vessels built. The *Black Eagle*, yacht, of 540 tons and 260 horse-power, the *Flamer*, of 496 tons and 120 horse-power, and the *Pluto*, of 365 tons and 100 horse-power, constructed by Mr. Lang; the *Fearless*, of 165 tons and 76 horse-power, and the *Myrtle*, of 116 tons and 50 horse-power, were constructed by Messrs. Fletcher and Fearnell; and the *Swallow*, of 133 tons and 70 horse-power, was constructed by Mr. Pitcher.

It is impossible to trace any uniformity in the disposition of power to the tonnage of the vessel, in those built up to this time. In these vessels the relation of horse-power to tonnage varies between the limits of 1 to 4·13 and 1 to 1·76. The *Monkey*, designed by Mr. Evans, had 1 horse to 2·65 tons burthen. The *Comet* and *Meteor*, by Mr. Lang, had power to tonnage, respectively, as 1 to 2·975 and 1 to 2·96; whilst his more recent constructions, the *Flamer* and *Pluto*, had it in the relations of 1 to 4·13, and 1 to 3·65. The *Black Eagle*, being a yacht, had a greater relative power, as 1 to 2·07. Sir Robert Seppings gave a rather small relative power: his first vessel, the *African*, had the proportion as 1 to 3·27; the *Alban*, as 1 to 4·05; the *Carron*, as 1 to 4·11; and the *Columbia*, as 1 to 3·61. Mr. Graham gave a power as 1 to 2·12 and 1 to 2·14. Messrs. Humble and Hurry gave 1 horse-power to 1·76, and 1 to 2·15 tons. Messrs. Fletcher and Fearnell gave a relative power as 1 to 2·17 and 1 to 2·32. And Mr. Pitcher gave a power as 1 to 1·9 ton.

From the year 1832 the construction of steamers was a charge held in the hands of the surveyor of the navy. Sir William Symonds did not proceed rapidly in building them, nor did he at once build any of large tonnage. His first steam-vessel was the *Gleaner*, built in 1833, of 351 tons burthen and 130 horse-power, and therefore with a proportion of power to tonnage as 1 to 2·7. In 1834 only two steamers were built,—the *Blazer* and *Tartarus*; the former of 527 tons and 120 horse-power, and the latter of 523 tons and 136 horse-power. Sir William Symonds's first large steamer was the *Volcano*, of 720 tons and 140 horse-power: she was built in 1836. It may be observed that this was the smallest relative power given to any steam-vessel in the naval service, being as 1 to 5·14. In the following year the *Gorgon* steam-sloop was built, of 1111 tons and 320 horse-power. The *Acheron*, steam-sloop, of 722 tons, and the *Medusa*, *Merlin*, and *Hydra*, each between 800 and 900 tons burthen, were built in 1838. The relative proportion of power was as 1 to 4·24 tons in the *Acheron*; in two of the others it was as 1 to 2·96; and in the last it was as 1 to 3·7. Five steam-sloops were built in 1839; the largest of which was the *Cyclops*, (Plate 37, fig. 1) of 1195 tons burthen, with a load displacement of 1862 tons, and 320 horse-power; the *Vesuvius*, of 970, and the *Stromboli*, of 967 tons burthen, both of them having engines of 280 horse-power; and the *Hecate* and *Hecla*, of 817 tons and 240 horse-power.

In 1840, whilst the building of wooden steamers was going on, after designs by the surveyor of the navy, in the *Minos*, to be employed on Lake Erie, *Driver*, steam-sloop, *Polyphemus*, steam-sloop, *Locust*, and *Medina*, packet, the *Dover*, packet, was built of iron by Mr. Laird, of Birkenhead. In the following year Mr. Laird built a second iron steam-vessel for

THE CYCLOPS, NAVAL STEAM SLOOP.



the government service; this was the *Albert*, of 456 tons burthen and 70 horse-power. The building of large steam-vessels and steam-sloops went on at a considerable rate; in 1841, besides two others, there were five sloops, from 1054 to 1059 tons burthen, with engines of 280 horse-power; and in 1842 there were four of the same tonnage, with engines of 300 horse-power; six other steam-vessels, varying from 70 to 813 tons burthen, with engines from 20 to 220 horse-power, were built in the same year, and also the *Firebrand*, steam-frigate, of 1190 tons, and 400 horse-power. The royal yacht, *Victoria and Albert*, of 1442 tons displacement and 400 horse-power, was built in 1843, whilst the building of steam-frigates and sloops still went on. From the year 1833 to 1843 there was no important competition to interfere with the plans of the surveyor in regard to steam-vessels. The general exclusion of collateral skill and judgment in designing steam-vessels, at a period of their history when the need of them was indistinctly perceived, and when, therefore, the best adaptation of form, dimensions, and power, for naval uses had to be ascertained by approximation, is perhaps the cause that the character of naval steamers did not advance more quickly towards the standard of required excellence.

In the year 1843 the *Penelope*, 46-gun frigate, was cut asunder in the middle, at Chatham dock-yard, and lengthened by the addition of about sixty-five feet, and had engines of 650 horse-power. This did not allow enough displacement for the greater weight she would be required to carry; hence the excess of weights in relation to the displacement, brought the vessel lower than was expected. An amount of alterations was made to restore a better external appearance; but this experiment has not been repeated.

If the *Penelope*, and all the other steam-frigates, had answered to perfection in their capacity to carry armament, stores, and fuel, it might have been inquired of those who wished to make them a part of the British navy, to what purpose of warfare may these vessels be put which would not have been fulfilled quite as well by vessels of far greater economy in construction and maintenance? What is the compensation of merely bow and stern guns of long range for the great expense at which they may be brought into use? Would not these be borne equally well by smaller vessels? Steam-vessels, propelled with paddle-wheels, are not suited to use a broadside armament, even if they can carry it, unless it may be in the *few* instances in which the machinery has been brought below the line of flotation. Even in these, the exposure of the broadside to conflict would risk the destruction of the paddle-wheels, and therefore the loss of any superiority to sailing ships.

In 1844 the official exclusiveness in the construction of steamers was broken through by the earl of Dundonald, who obtained the approval of the Admiralty to a plan he submitted for a steamer of 763 tons, having the bow and stern alike; the sections were similar, and were formed of semiellipses: she was called the *Janus*. The engines, of 200 horse-power, were also on his own plan; but as they did not answer well they have been taken out, and common engines have been put into their place, with which she has improved.

In the same year the *Porcupine*, of 382 tons burthen and 140 horse-power, was built on a plan selected by the board of Admiralty; whilst several steam-frigates, after the surveyor's plans, were launched—as the *Retribution*, of which a few particulars have been mentioned; the *Sampson*, of 1299 tons and 450 horse-power; and the *Scourge*, of 1124 tons and 420 horse-power; and two iron gun-vessels, of 340 tons burthen, and 150 horse-power, built at Glasgow.

In 1845 there was a still wider infringement of the exclusive privilege of construction. Messrs. Ditchburn and Mare built the *Fairy*, her Majesty's yacht tender, of 312 tons and 128 horse-power: she was fitted with a screw-propeller. They built also the *Myrmidon*, of 370 tons and 150 horse-power: these were both built of iron. Mr. Robert Napier, of Glasgow, built the *Bloodhound*, also of iron, of 378 tons and 150 horse-power. And Mr. Lang built the *Terrible*, steam-frigate, of 1850 tons and 800 horse-power. The only steamers on the surveyor's plans, that were launched during the year, were two iron gun-vessels, built at Blackwall.

In the years 1846 and 1847 competition increased; but plans for building ships were received by the Admiralty on different conditions. The Admiralty formed a "Committee of Reference," including two shipwright officers and Dr. Inman, the late professor of mathematics at the Royal Naval College, with captain Lord John Hay as its chairman; and they now referred all designs, as well those of the surveyor as of other persons, to this committee for investigation, before adopting them. This is not the place to inquire into the soundness or unsoundness of the principle which admits of general competition under common circumstances. The harmony of arrangements is likely to be disadvantageously interfered with by great latitude in this respect; for the objects of such an administration should be most definite in themselves, and distinctly relative to each other. But it is clear enough that circumstances may occur in which the range of competition may be large, and yet limited by such conditions that it shall not be injurious; and the state of an administration may be quite easily apprehended, in connection with which it may be most necessary to educe talent and exercise skill wherever they may be found. The effect of such a course under the late and the present boards of Admiralty, has been to lay the foundation of a most necessary reform, not only in the construction of steam-vessels, but also of sailing-ships. It was the means of demonstrating the error which had prevailed year after year of building large steam-ships whose armament must be limited to bow and stern, and four broadside guns; for it has shown that vessels of much less tonnage and power of machinery could carry as powerful an armament, be equally fast under steam, and supply as great space for the conveyance of troops. It may also be observed, that the steam-frigates which this expedient policy has been the means of bringing into the navy are, unlike a number of those which preceded them, frigates, as well in the efficient armament they bear, as in the imposing appearance of large dimensions and broadside ports.

There are two objects yet to be noticed, towards which special efforts have been directed with success. The production of steam-frigates able to carry and use broadside armament on the main deck, was regarded by the late board of Admiralty as so important, that they gave instructions in February, 1845, for the building of the *Odin*. The results aimed at in constructing this ship were,—capability of carrying broadside armament; diminished rolling, in comparison with any war steamers then built, that she might be able to use such armament; and less draught of water in relation to the size. These objects were accomplished; but as the position of the machinery and boilers is partially above the water-line, and the propellers are exposed to danger in broadside fighting, the ship is necessarily imperfect in these two conditions, as well as in the position of her sails; for in this case the proper place of the mainmast was occupied by the boilers, and consequently the centre of effort of the wind on the sails is in a wrong place.

Rear-admiral sir Charles Napier, observing the conditions that were aimed at in the lines of this ship, fully appreciated the object; but he saw the importance of including another condition,—that of protecting the machinery, boilers, and steam-chest, by placing them below the water-line. He therefore obtained permission to present a plan for a steam-frigate to include that condition, and also to carry more coals. This was the *Sidon*. He further obtained permission of the board of Admiralty, and of the constructor of the *Odin*, to use the lines of that ship for the *Sidon*, with some alteration in the principal dimensions, especially in the depth of the hold, which was greater by 2 feet 9 inches. By this means greater space was obtained for the stowage of coals, and iron tanks were placed in the hold to contain them; and these tanks are filled with water when the coals have been removed, and the ship's draught of water is rendered less variable, a result of considerable value to the effective working of the paddle-wheels; but she has less stability than the *Odin*. The order to build this ship was made on the 26th May, 1845; but the execution of it was hurried, and the *Sidon* was launched before the *Odin*. Sir Charles Napier fulfilled his purpose in the *Sidon*; but the danger common to all paddle-wheel steamers, of having their propellers exposed in lateral engagements, is still a defect.

The most successful effort at producing fast steamers has resulted from the competition which the board of Admiralty induced for separate designs for four steam-packets, to occupy the station between Holyhead and Kingstown. The four constructors who submitted plans for these vessels were sir William Symonds, for the *Caradoc;* Mr. Oliver William Lang, of Chatham dock-yard, for the *Banshee;* Messrs. Miller and Ravenhill for the *Llewellyn;* and Mr. John Laird, of Birkenhead, for the *St. Columba.* The following table states the principal dimensions of these vessels, and also some other information, showing their actual and relative capabilities of speed.

PARTICULARS.	*Caradoc.*	*Banshee.*	*Llewellyn.*	*St. Columba.*
	ft. ins.	ft. ins.	ft. ins.	ft. ins.
Length between perpendiculars	193 0	189 0	190 0	198 6½
Breadth of vessel	26 9	27 2	26 6	27 3
Breadth over paddle-boxes	—	49 6	—	43 6
Depth in hold	14 9	14 9	—	15 5
Draught of water . . { forward . .	—	8 10	—	9 2
aft . . .	—	9 2	—	8 7½
Light displacement in tons	260	270	323	272
Burthen in tons	662	670	654	719
Diameter of paddle-wheels	25 6	25 0	30 0	28 0
Nominal horse-power of engines . . .	350	350	350	350
Diameter of cylinder in inches	74	72	68	70
Length of stroke	6 0	5 6	4 4	5 6
Revolutions per minute	28	30	27	25½
Breadth of paddle-wheel	8 0	9 0	8 6	6 0
Dip of paddle-wheel	—	5 6¼	—	5 6½
Area of paddle-wheel	—	33 9	30 10½	27 0
Area of the midship section	—	190 0	—	—
	h. m. s.	h. m. s.	h. m. s.	h. m. s.
Time occupied in making the shortest passage between Holyhead and Kingstown, from the 1st Aug. to the 31st Dec., 1848	4 0 0	3 26 0	3 41 0	3 56 0
Rate in knots per hour	14·0	16·32	15·2	14·23
Rate in miles per hour	16·13	18·80	17·5	16·37
Time of longest passage	5 52 0	5 23 0	5 28 0	6 23 0
Rate in knots per hour	9·5	10·4	10·24	8·77
Rate in miles per hour	10·94	12·0	11·79	10·10
Average time of passage	4 30 0	4 2 48	4 15 30	4 38 48
Rate in knots per hour	12·45	13·84	13·10	12·05
Rate in miles per hour	14·34	15·95	15·10	13·00
	lbs.	lbs.	lbs.	lbs.
Pressure on the safety-valve	14	14	20	14
	h. m. s.	h. m. s.	h. m. s.	h. m. s.
Time of making the shortest passage, from 1st Jan. to 1st March, 1849, . . .	3 59 0	3 36 0	3 37 0	4 8 0
Time of longest passage	5 16 0	7 43 *0	4 50 0	6 30 0
Average time of passage in 1848-9 . . .	4 31 25	4 3 8	4 9 30	4 40 42
Shortest time of passage, from 1st Aug. to 1st Oct., 1849, ...	3 54 0	3 26 0	3 36 0	4 3 0
Average time of passage, from 1st Aug. to 1st Oct., 1849, ...	4 26 0	4 3 0	4 6 0	4 40 0

The ordinary performances of these four packets, as well as their performances especially under trial, have determined their relative merits. Their service is one that demands at all times the greatest effort that can be made; and therefore it is, no doubt, quite fair to conclude that they have done all that they are capable of doing, and that the following order of merit is strictly correct: *Banshee,* first; *Llewellyn,* second; *Caradoc,* third; *St. Columba,* fourth. It will be observed that the pressure of steam, kept up, was the same (14lbs. on the valve), in all except the *Llewellyn,* in which it was 20 lbs. Sufficient time has elapsed to sanction the inference thus drawn of relative excellence as to speed, whilst there is no doubt that each of them bears a character of very high order.

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* This passage was made in a state of weather so bad, that no other steam-packet ventured to attempt it on that day.

In looking at the capabilities of steam-vessels at the time of their earliest use, and at the present time, it is evident at the first glance, that improvements in them have been very great. The second thought is, wherein do the improvements consist? Very brief inquiry leads us to a knowledge of the fact, that improvements have been made both in the form of the vessel, and in the character of the engine. From this point the inquiry is involved in more difficulty, inasmuch as the alterations which have developed the improvements have gone on simultaneously. Improvement in steam-vessels commonly implies increase of speed. Now, although the water always presents a similar resistance to similar bodies moving at the same velocity in it, yet the facility of overcoming that resistance varies under varying conditions, in vessels which have the same area of midship section. This fact has been clearly apprehended by constructors of steam-vessels, whilst the law which determines the variations in the conditions remains yet unknown. Hence, whilst vast numbers of trials have been made to obtain greater speed in steamers, by means of the form of body, they have been so many experiments not controlled by law, but aiming simply to realise advantageous results. These have been obtained; but they are yet involved with those of other conditions, in a way that seems at present to defy analysis. Experience has shown, that with the same area of midship section, different water-lines are best suited to different degrees of speed; but this condition remains to be defined.

Experience has obtained great improvements in the character of marine steam-engines and boilers; the engines, not only in weight, and in the space which they occupy, but in the workmanship, and in the arrangement of their parts. Formerly the pressure on every square inch was only from four to six pounds above the pressure of the atmosphere, making a positive pressure of not more than twenty pounds, and the whole effective power of the engine was seldom more than twice the nominal power; often it was much less. Now the positive pressure is sometimes forty pounds on a square inch, and the real power becomes four or five times the nominal power. Hence, with the same nominal horse-power of engines that was used formerly, there is now a great accumulation of actual force. This is, undoubtedly, a cause of no inconsiderable measure of the increase of speed which has been obtained. The production of greater results by the same nominal force appears at first to be a highly valuable improvement in point of economy, effected in marine steam-engines; and to some extent improvement may have gone in this direction; but as the current expense of an engine depends chiefly on its consumption of fuel, and as a given quantity of fuel is capable of generating only a given quantity of heat, the measure of economy is perhaps much less than is commonly apparent in many of the engines of the most modern construction.

With the same machinery, the force varies under different circumstances, as the pressure of steam and the vacuum at any time of trial; and, under some circumstances, the effective power of the engine may not only be reduced, but the resistance on the body may be increased; for if the power does not act in such a direction that the effort to impel the vessel shall pass through, or in a proper relation to the mean resultant of the pressure of the water on the bottom, the correct water-line of the body is forced from its parallelism to the surface of the water, becoming depressed at one or the other of its extremities; and when the direction of the force is not the same as that of the motion of the body, a part of the power of the engine is thereby lost. The deviation from parallelism is increased by the elevation of water at the bow, and its depression at the stern, of a vessel going at a great velocity. The place of the mean resultant of the water on the body will vary with differences of form.

The two general causes just noticed have long been in combination, producing the improvement now under consideration; but the instances in which one cause has operated apart from the other have been comparatively few, and the results of these have been so insufficiently marked and recorded, that there are not data enough to show how much of the general result is owing to one cause, and how much of it is due to the other. In fact, steam navigation has all along been a matter of commerce rather than of science. It has not unfrequently happened that a steam-vessel has failed at first of fulfilling the purposes for which she was intended, and alteration has been necessary. In some of these cases the form has been altered by lengthening the bow, or increasing the fineness of the run; and, at the same time, the machinery has been improved also. The result has been a satisfactory increase of speed; but the compound character of the alteration makes it impossible to tell definitely how much is a consequence of each cause respectively. Without questioning that much of the improvement in the speed of steam-vessels has resulted from alterations in the form, it can hardly be doubted, considering the actual improvement which is known to have been made in the machinery, that the larger proportion of improvements in steam-vessels has resulted from this cause.

There is, however, good evidence that sharp or lengthened bows are generally advantageous *in mercantile steam-vessels.* Their weights are not so distributed as to require the same degree of buoyancy at the extremities that is necessary in war steamers. For commercial purposes speed is usually a primary consideration. In war steamers the requirements are somewhat different; for whilst speed is *never of small consideration*, other conditions have to be connected with it; and great speed takes the place of a secondary quality: the capability of bearing armament well, and of using it, is of course prior in importance to other qualities, as no others would compen-

SECTIONS & DIMENSIONS OF STEAM VESSELS.

Fig 1

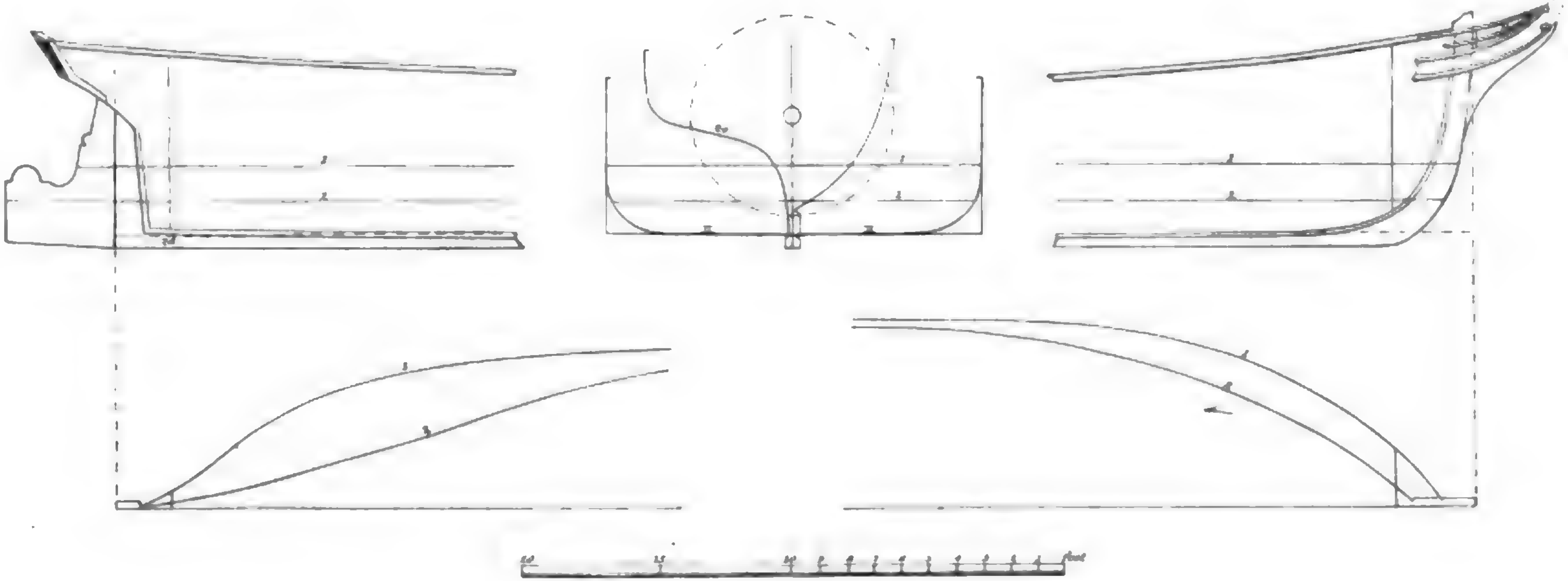
Sons of Commerce

Gravesend Packet built in 1817.

Dimensions

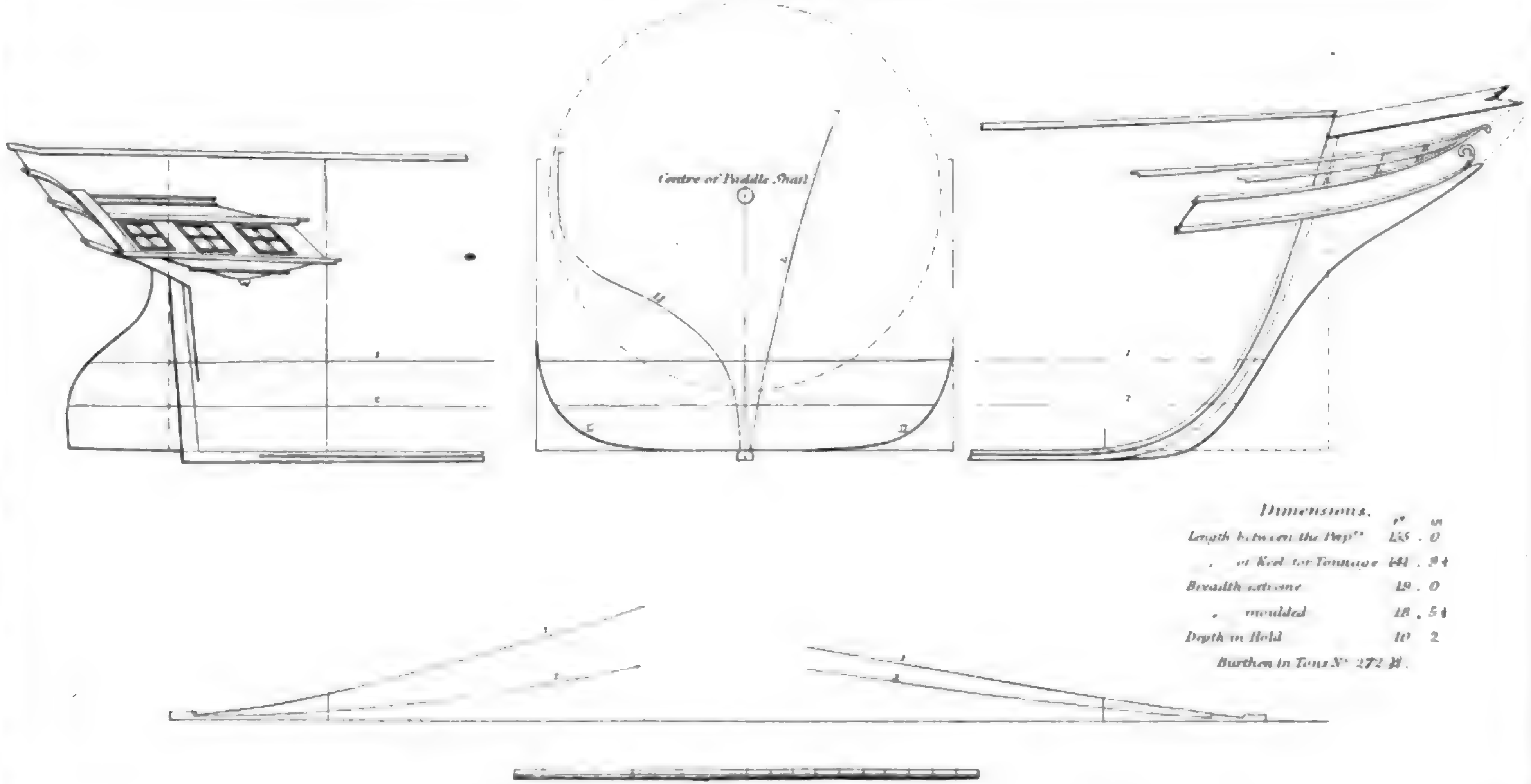
	feet	in.
Length between the perpˢ	85	0
" of Keel for Tonnage	76	7
Breadth extreme	14	0
" moulded	13	9
Depth in Hold	4	4

Burthen in Tons Nº 79 [illegible]



SECTIONS & DIMENSIONS OF STEAM VESSELS.

Gravesend Packet built in 1846.

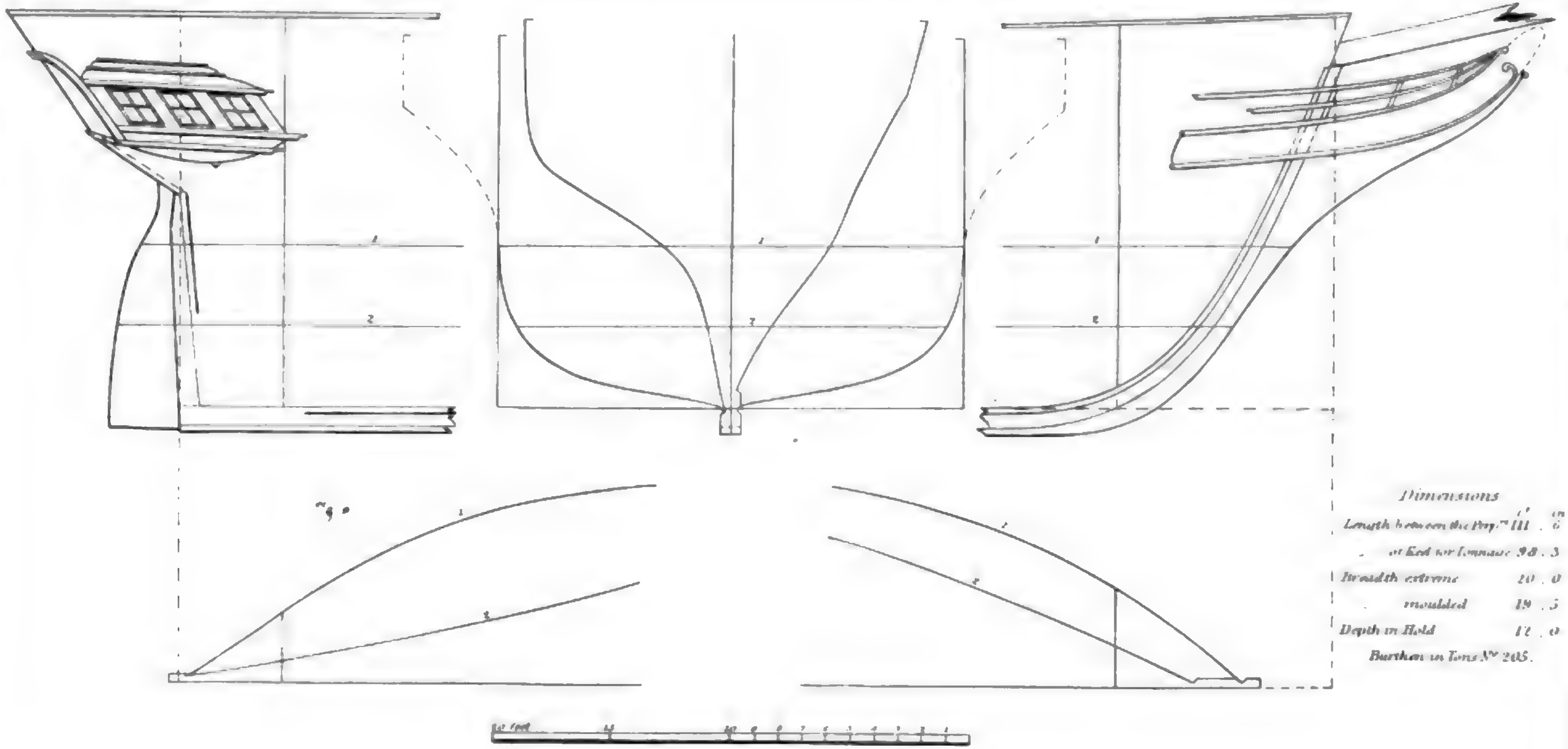


Dimensions.	F	In
Length between the Perp^rs	155	0
„ of Keel for Tonnage	141	9¼
Breadth extreme	19	0
„ moulded	18	5¼
Depth in Hold	10	2

Burthen in Tons N° 272 ⁴⁄₉₄.

SECTIONS & DIMENSIONS OF STEAM VESSELS.

Steam Packet built for Norway by Mr. Evans



Dimensions

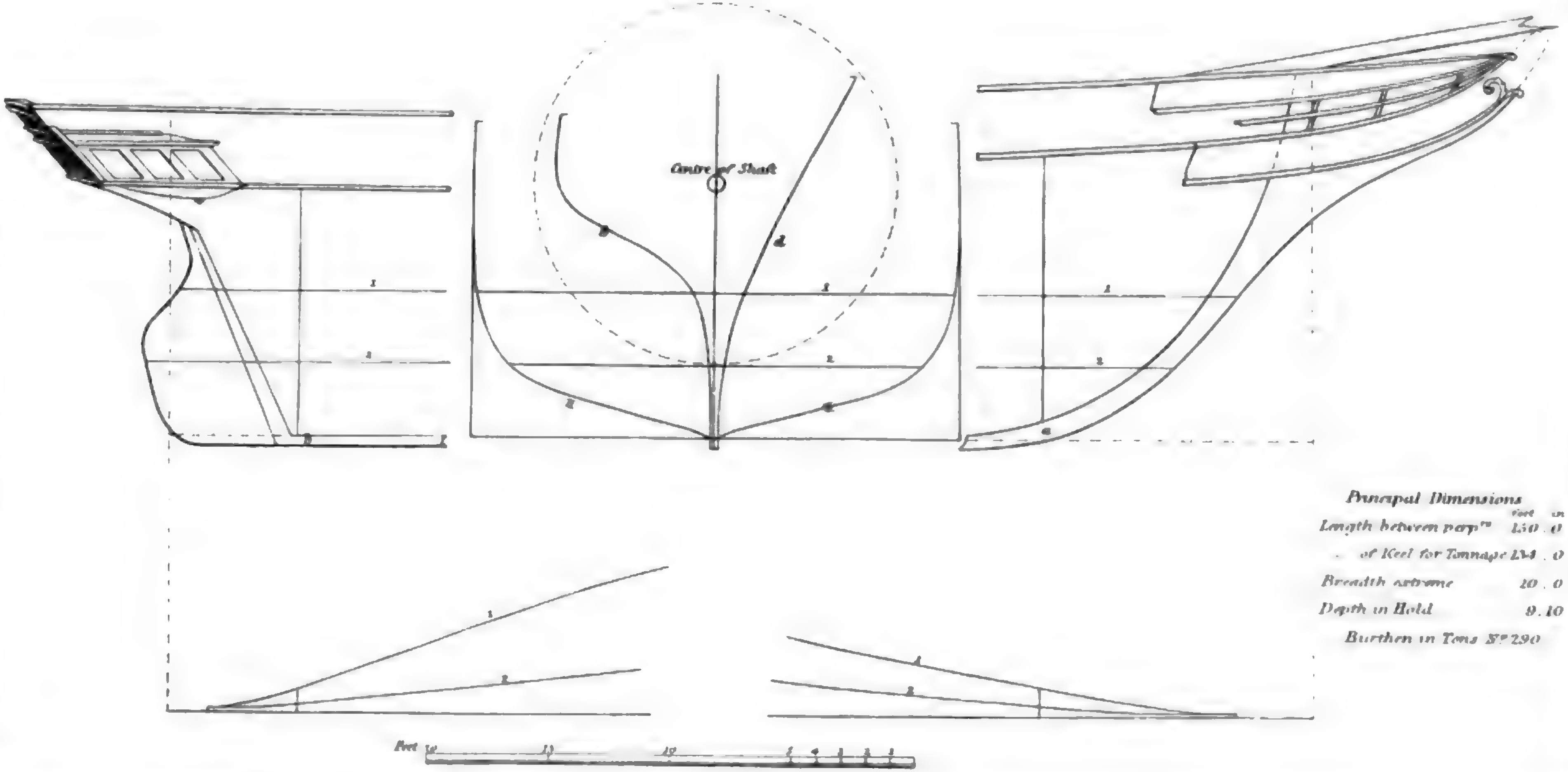
	ft	in
Length between the Perp.rs	111	6
— at Keel for Tonnage	98	3
Breadth extreme	20	0
— moulded	19	5
Depth in Hold	12	0

Burthen in Tons No. 205.

SECTIONS & DIMENSIONS OF STEAM VESSELS.

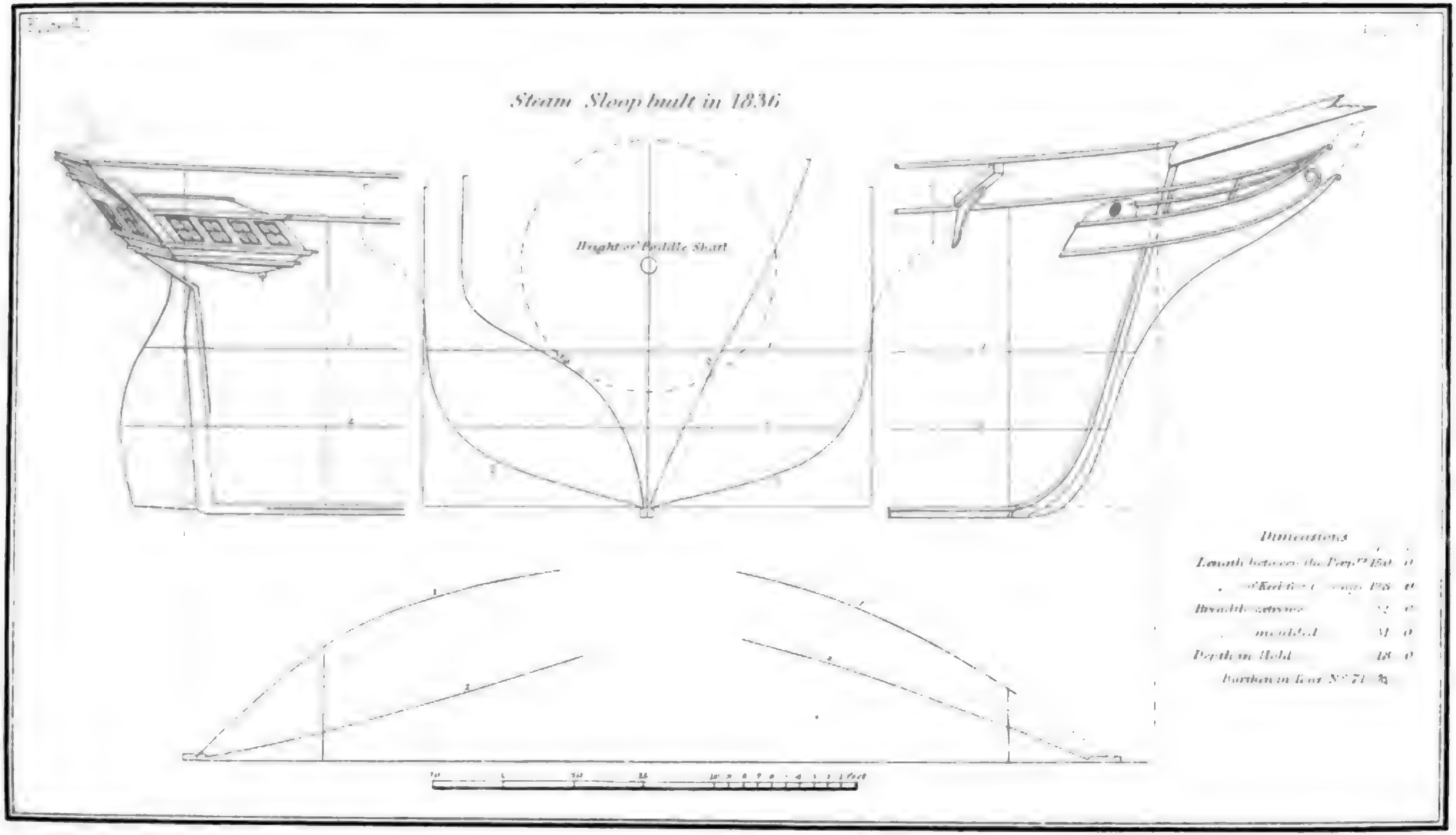
Plate 41

Steam Packet for Crossing the Channel, built in 1845.



Principal Dimensions	feet . in
Length between perp^rs	150 . 0
„ of Keel for Tonnage	134 . 0
Breadth extreme	20 . 0
Depth in Hold	9 . 10
Burthen in Tons Nº 290	

SECTIONS & DIMENSIONS OF STEAM VESSELS.



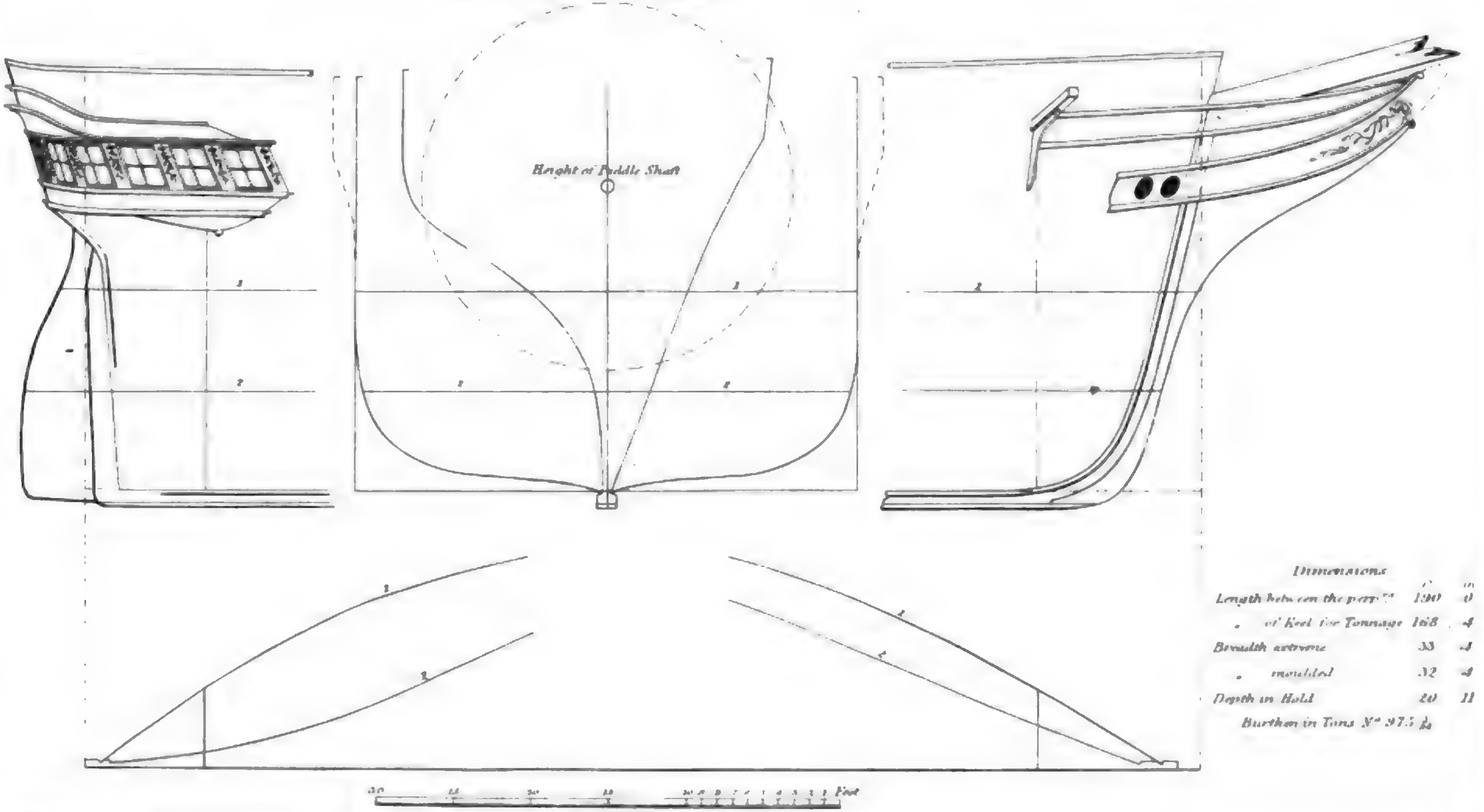
Steam Sloop built in 1836

Dimensions

Length between the Perp.rs	150	0
" of Keel for Tonnage	128	0
Breadth extreme	32	6
" moulded	31	0
Depth in Hold	18	0
Burthen in Tons No. 71	8	

SECTIONS & DIMENSIONS OF STEAM VESSELS.

Steam Sloop built in 1849.

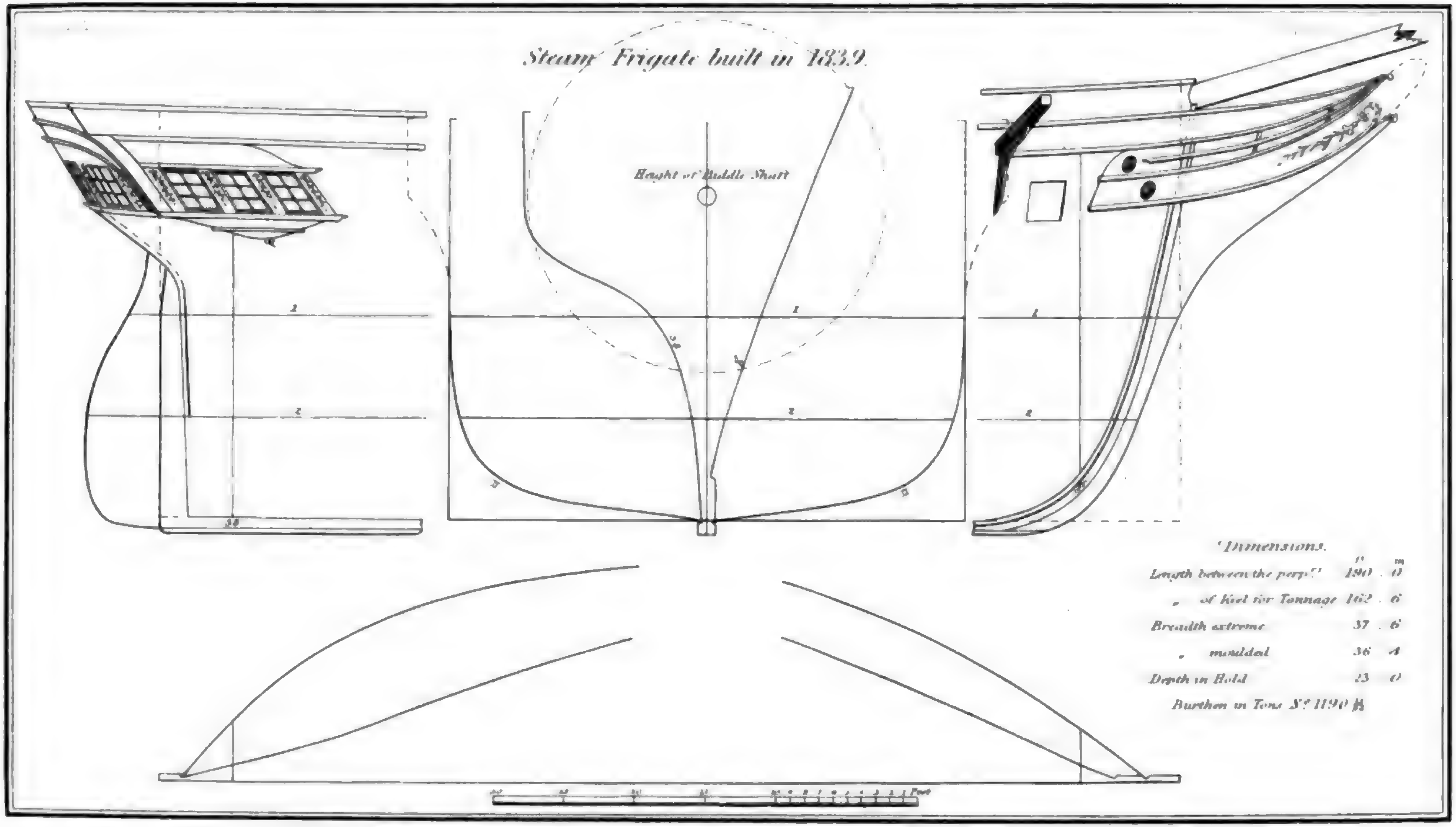


Dimensions

	ft	in
Length between the perp.rs	190	0
„ of Keel for Tonnage	168	4
Breadth extreme	33	4
„ moulded	32	4
Depth in Hold	20	11

Burthen in Tons N° 975 [illegible]

SECTIONS & DIMENSIONS OF STEAM VESSELS.



Steam Frigate built in 1839.

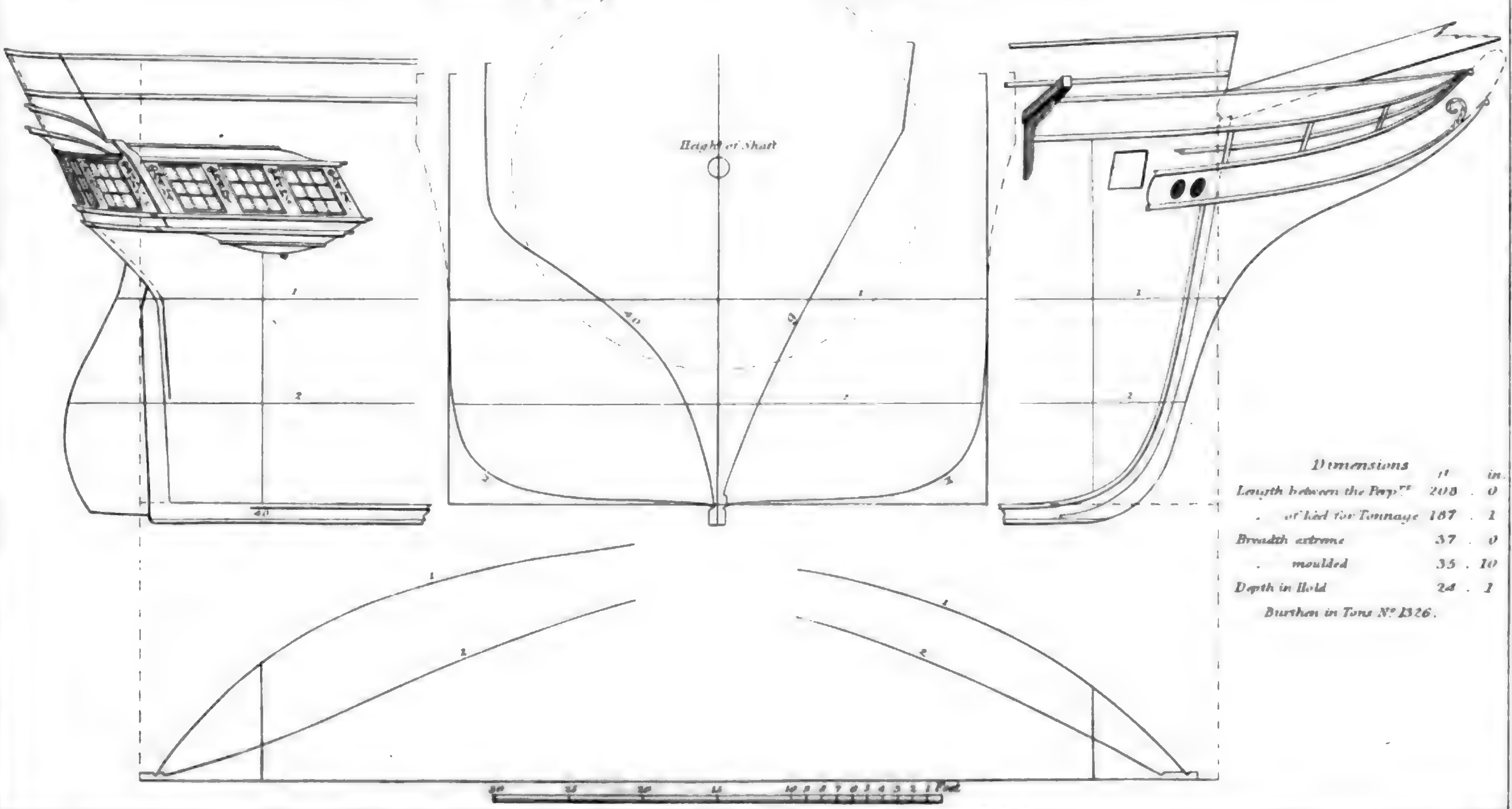
Dimensions.

	ft	in
Length between the perp.^rs	190	0
" of Keel for Tonnage	162	6
Breadth extreme	37	6
" moulded	36	4
Depth in Hold	23	0
Burthen in Tons N.º 1190 $\frac{18}{94}$		

SECTIONS & DIMENSIONS OF STEAM VESSELS.

Plate 4.

Steam Frigate Built 1846.



Dimensions	ft	in.
Length between the Perp^{rs}	208	0
. of Keel for Tonnage	187	1
Breadth extreme	37	0
. moulded	35	10
Depth in Hold	24	1

Burthen in Tons Nº 1326.

sate for the want of this. Heavy guns at the extremities of war steamers are always deemed essential to their armament. These require to be supported by a buoyancy that would not be realised with the degree of sharpness which is admissible in commercial steamers. In order, therefore, to restrict the motions of pitching and 'scending within moderate limits, in war steamers, the advantages of speed which result from extreme sharpness must be foregone; but whilst war steamers are under that condition, the limitation of sharpness to the bow is not such as to hinder a degree of speed which is little short of that obtained on an average by sea-going steamers employed in commerce. Observation has yet failed of determining the limit which is best for the bows of war-steamers, all things being considered. It has, however, been observed, that although a steamer with a sharp bow does not rise to the waves so much as a full-bowed vessel, yet she divides them with a degree of facility which gives her an advantage about equivalent to that of greater buoyancy in the full-bowed vessel, especially when pressed against a head sea.

That the form of steam-vessels has been considerably altered since their introduction, may be seen by reference to plates 38, 39, 40, 41, 42, 43, and 44. Plate 38 shows the form of one of the first steam-vessels intended to run short distances, with passengers only. Plate 39 shows one of the last and most improved forms. Plate 40 shows the form of a vessel built by Mr. W. E. Evans, to be sent to Norway; and Plate 41 shows that of one of the more modern steamers, built for crossing the British Channel. The forms of war steamers are shown in plates 42 and 43; that shown in plate 42 is a steam-sloop, built in 1836; and that in plate 43 is a steam-sloop, built in 1849; plate 44 shows the form of a steam-frigate, built in 1839; and plate 45, that of a steam-frigate, built in 1846.

From the time when steam navigation became appreciated in this country, much talent and ingenuity were employed to diminish the imperfections of the machinery and the paddle-wheels, as a system; and when we regard the magnitude of the interests associated with steam navigation, we cannot fail of observing that such an object was worthy of the eminent talent which distinguishes the civil engineers of Great Britain. Their success was partial, but no more. It seems that the system is essentially imperfect, for whilst paddle-wheels may perhaps possess superior advantages in the navigation of rivers, in which there is but a small depth of water, still nothing has been even promised, to realise, in their working, a uniform effect in heavy seas.

In this state of steam navigation a propeller, including the effective power of paddle-wheels, without their defects, must be of great value. The idea of employing a screw for such purpose, which had at different times received a cursory attention, now produced a fixed purpose of actual usefulness. The well-known fact of the screw-pump's having been the invention of Archimedes, excludes all pretension to modern originality, either as to the form of the instrument or to its power to act on a fluid. The great merit of making the screw available to the propulsion of ships seems to consist, rather in the simplicity and efficacy of its application, than in inventive genius; for the power of a helical blade in water was proved in the use of the pump.

The application of the screw, or helical blade, to the propulsion of vessels, was suggested, if not acted on, in France, at least 120 years ago. In an appendix to "Tredgold on the Steam-engine," the writer, Mr. Elijah Galloway, gives a description of the arrangement, from a work entitled "Machines et Inventions Approuvées par l'Académie Royale des Sciences depuis 1727 jusqu'au 1731." The contrivance was made by M. Duquet, and its object was to draw vessels up a river against the current. The screw consisted of a helical blade, forming one turn and a-half on an axis; and it was suspended upon bearers placed between two boats, fixed in a position parallel to each other. These two boats were intended to be stationary, and the screw to be put in motion by the force of the current. On one end of the axis there was a grooved wheel connected with two other pulleys, fixed on frame-work for the purpose, and giving motion to ropes attached to two vessels, which partially balanced each other, and the required motion was intended to be given by this means. The diagram copied from the original work by Mr. Galloway, represents the screw to be suspended nearly out of the water: in this condition it is evident that no use could be made of it; and the velocity which it could take from the force of the current, even if it had been correctly placed, may hardly be supposed enough to overcome any considerable resistance.

In the year 1768 a little book was published at Paris, under the title of "Théorie de la Vis d'Archimede," by M. Paucton. Besides treating of the screw as an hydraulic machine, the author suggests two uses of it in navigation. The first of these is to ascertain the speed of a ship. He says, "if it were made on a small scale, and placed under the water in the direction of the ship, it would communicate its movement to wheels which would measure the way much more exactly than the log which seamen use."

The next use to which it was proposed is the propulsion of vessels. After describing the mechanical operation of the oar, as a lever, he says, "I am surprised that no one has proposed to change the form of the common oar," seeing that no inconsiderable portion of the power employed in working it does not operate directly to the progress of the boat. He therefore introduces his own proposal for the change which he thought desirable. "To remedy this inconvenience, it would be necessary to substitute for the common oar an instrument whose action might, if possible, be uniform and continuous: now I think this property exists in perfection in the *ptérophore*. Two of these may be placed horizontally, and parallel to the length of the vessel, one each side, or one only at the fore part. The *ptérophore* will be immersed entirely in the water, or only up to its axis, &c., as it is desired.

The size of the *ptérophore* will depend on that of the vessel, and the curvature of the blade on the velocity which it is proposed to produce."* The description given of the *ptérophore* is, that it is an instrument composed of a circumvolution of a helical blade about a cylinder; the radii in this blade being at right angles to the axis.

Prior to any experiments in England, which I have found recorded, of steam propulsion, by means of either the paddle-wheel or the screw, we find a patent taken out by Joseph Bramah, in 1785, for the use of both these instruments, "for the purpose of rowing or forcing ships and other vessels in calm weather."† One instrument is described as being "like the water-wheel of a mill or engine," and was required to be partly out of water; the other is described as having "inclined fans or wings, similar to the fly of a smoke-jack, or the vertical sails of a windmill:" this had to be "wholly under water." Both instruments were to be fixed at the stern of the ship, and the moving power was intended to be "a steam-engine on the rotatory principle." It does not, however, appear that the truly ingenious author of the plan ever reduced it to experiment.

The next effort in England bearing upon this subject appears to have been the taking out of a patent by Mr. William Littleton, a merchant of London, in July, 1794, for a screw-propeller, to be worked by means of a capstan turned by men. I do not find that it was ever used.

The next step we are acquainted with was the application and use of a propeller patented by Mr. Edward Shorter, of London, in February, 1800. The record that has survived of this fact does not inform us what was the form of the propeller, nor how it was applied; but as it was used in the *Doncaster*, transport ship, in 1802, it was worked by means of a capstan, and it propelled the ship at the rate of a knot and a half an hour. Mr. David Napier had an opportunity, many years after that event, of seeing the result of Mr. Shorter's ingenuity and labours in models of a great variety of propellers, and in different methods of their application to ships; but it seems not to have transpired what was either the form or mode of application of the propeller used in the *Doncaster*. His propellers consisted of screws with one thread, two, three, and four threads; and also of narrow blades or arms, projecting from an axis; and he had contemplated the fixing of them in the dead wood as well as at the quarters of ships. It does not appear that any further application of Mr. Shorter's propellers was made.

In June, 1815, Mr. Trevithick, of Cambourne, in Cornwall, took out a patent for a fixed screw propeller, to work in a cylinder; and in 1816 Mr. John Millington, an engineer of London, patented the use of a propeller similar to a smoke-jack, to be placed abaft the rudder, and to be worked with a universal joint.

At this time (1816) Mr. Robertson Buchanan called attention to this subject in his "Practical Treatise on Propelling Vessels by Steam," &c., in which is the following passage: "Experiments have been made on a kind of screw; but this, I believe, after a trial on a considerable scale in America, was rejected."*

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* Pp. 208--210.

† Specification.

Of the attention which was given to this subject in America, we know but little beyond the mere plans that were formed. Marestier† has supplied us with the information he was able to obtain there; but he includes the forms of propellers which had been only proposed, with those which had been tried, and does not indicate the distinction. "Some," he says, "are manifestly complicated; others ill disposed; all are, perhaps, inferior to the means hitherto employed." He describes a "*helical surface*," or the screw-propeller, applied in two ways: first, as partially enclosed in a channel formed in the bottom of a boat, and extending nearly her whole length, forming three turns upon its axis. The moving power was applied to a vertical axis at the stern of the boat, and communicated to the screw by means of two bevel wheels. Another arrangement of the *helical surface* was that of two screws, each of them consisting of two turns upon its axis, placed between two boats. The boats were parallel to each other, and the screws also; but these were formed to work in opposite directions, and they appear to have occupied in length nearly half that of the boats. Two horses were required to give motion to these screws; but it does not appear that either of these plans had been reduced to the test of experiment. Many arrangements for the propulsion of vessels were pointed out in that book; perhaps few of them were ever of any service. After describing twenty plans, M. Marestier says, "I have made no remark on the inconveniences of the various combinations of which I have just given an idea, because they are generally evident enough."

Necessity sustained the impulse which had been formed, for the contrivance of something preferable to paddle-wheels; but it was left to England to supply the desideratum. And in the year 1825, a premium was offered for the best plan of propelling vessels without paddles; and one was proposed by commander Samuel Brown, R.N., and accepted. A patent was taken out for this on the 15th of March. The propeller was formed of two blades, projecting from an axis with which they formed an angle of 45°, and placed at the head of the vessel, where, by means of joints, it was capable of being raised out of the water without being disconnected. It was worked by a 12-horse power engine. The results of the few trials that were made seem to have been satisfactory; for commander Brown built a second vessel, which he fitted up with the same machinery; and in this instance, the results, more distinctly recorded, appear to have been more decidedly successful. The project was nevertheless given up by him.

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* See also note, ante, p. 285.

† Mémoire sur les Bateaux à Vapeur des Etats-Unis d'Amérique, &c. Paris, 1824.

In December, 1828, Mr. Charles Cummerow, a merchant of the city of London, took out a patent for a screw-propeller, formed of one complete turn of the blade upon its axis, to be fixed abaft the rudder, parallel to the line of the keel. And in July, 1829, Mr. Jacob Perkins, of London, engineer, patented the use of a propeller, formed of two blades, to be fixed at the stern of the vessel.

All these efforts, viewed in connexion with the available power of steam, indicate that the maturity of art now required the full development of the principle and efficacy of the screw, as applicable to navigation. The progress of experiment had become too extensively known to allow the subject to sink again into oblivion; and if success had not been adequate to the efforts, attention had been excited on both sides of the Atlantic; and the investigation of the subject was recommended by several eminent engineers.

In March, 1832, Mr. Bennet Woodcroft took out a patent for "Certain improvements in the construction and adaptation of a revolving spiral paddle, for propelling boats and other vessels on water." That was the screw-propeller, which is now generally known by the particular condition of its increasing pitch. He calls it "a spiral worm, blade, or screw coiled round a shaft or cylinder, of any convenient length and diameter." The situations proposed, in the specification of the patent, for the working of this screw, were, the sides of the vessel and "under the stern," to be worked by steam-power. Little was known of this propeller for several years. It appears not to have attracted the notice of those who were most ardently interested in the same object; but in 1842 a vessel, built for commercial purposes, was fitted with it.

Mr. Woodcroft's claim to priority of design will not be considered here, beyond the statement of facts proving that ingenuity had been applied to the same object, and had accomplished, some years previously, about as much as he accomplished, except the peculiarity of his screw; for the design had been truly conceived already, and the condition necessary to the success of the project was, the right place for the screw to work. So little seems to have been known of his plan, that when Mr. Smith and captain Ericsson were developing the actual power of the screw in their respective forms, they were regarded as original by engineers as well as by others. Up to that time, then, his screw had scarcely been an object of attention. Regarding the three patentees as the individual authors of their separate plans,—as, for any thing that appears to the contrary, it may be readily admitted that they formed their designs apart from each other, and from any other person who had formed similar projects,—they appear to be meritorious according to the value of their productions. But something must be indicated beyond the *design*, to which merit attaches; and that is, the energy of character which could hope under almost universal neglect and distrust, and persevere for years against the most general discouragement, until the proofs of their designs were on such a scale and in such a light, that they *must* be seen, and their intrinsic excellence be acknowledged. Omitting, therefore, any further notice of Mr. Woodcroft's propeller, which is described in his own book, the following observations will indicate the progressive development of the same principle, in the more simple form and application of the screw selected by Mr. Smith, and that which was, about the same time, brought out by captain Ericsson.

In May, 1836, Mr. Francis Petit Smith took out a patent for the Archimedean screw-propeller, and in the following July, captain Ericsson took out the patent for his propeller. These things were presented to the public in the character of novelties; and as such they were regarded by the few who had curiosity enough to look at them, or on whose attention they were urged. Perhaps the year 1836 was the most important era in the history of the screw-propeller, for that was the period in which the capabilities of the two forms of screw were determined, which, after much patient labour on the part of their projectors, have become deservedly popular in Europe, and in the United States, respectively.

Mr. Smith's patents were for the application of the screw to propel steam-vessels by fixing it "in a recess or open space formed in that part of the after part of the vessel commonly called the dead-rising or dead-wood of the run," in the middle line of the dead-wood; and in comparison with other efforts which had been made to adapt the screw to the propulsion of vessels, the striking and peculiar merit of Mr. Smith's plan appears to consist, *chiefly*, in his having chosen the right position for it to work in.

At the same time that Mr. Smith was employed in his experiments on the power of the Archimedean screw, revolving rapidly in water, captain John Ericsson, formerly an officer in the Swedish army, but then a civil engineer in London, was engaged in experiments upon a propeller formed on the same general principle, though less simple in construction and application than that of Mr. Smith. The patent which he took out for his propeller bore date the 13th July, 1836, six weeks later than the date of Mr. Smith's patent.

The powers and adaptation of Mr. Smith's invention were first tried in a small vessel 34 feet long, 6 feet 5 inches in breadth, 6 tons in burthen, and 4 feet draught of water. The diameter of the screw was 2 feet, and its pitch 2 feet 5 inches. The diameter of the cylinder was 6 inches, and the length of the stroke 15 inches. At first the screw consisted of two turns of a single blade upon a long axis. The experiment was made in the City and Paddington canal; and, whilst it was in progress, a part of the blade broke off accidentally, when the boat immediately shot ahead at a sensibly greater speed.

The first trial with this vessel in the river was made on Saturday, the 20th of September, 1837, when she left Blackwall at 6 o'clock in the evening, and reached Gravesend at half-past 8. The next morning, at half-past

3, she left Gravesend, and made the Nore Light at 20 minutes before 6; Herne Bay at 25 minutes past 7; and arrived at Margate at a quarter before 10 o'clock; completing the distance in 8¼ hours. On Monday morning, at 6 o'clock, the vessel left Margate; but as she was going round the North Foreland, a feed-pipe gave way, and she reached Broadstairs under sail. On Tuesday morning she started for Ramsgate, and, leaving that port, she passed through the Downs to Dover, and afterwards proceeded to Folkstone. Here several days were employed in making a series of experiments, both as a sailing-vessel and a steamer, giving entire satisfaction in all her performances. In returning to Ramsgate she had to oppose a strong wind and a heavy sea; but it was still worse in returning from Ramsgate to Margate; the wind blew dead upon the Foreland, and the sea broke continually into the boat, nearly filling her. Yet, in a state of wind and sea, which it was thought would have rendered it impossible for a steamer fitted with paddles to weather the Foreland, this little boat reached Margate in safety, within the short space of 2 hours and 10 minutes. She returned afterwards to Blackwall, having traversed more than 400 miles at an average rate of 8 miles an hour.

The screw must, of necessity, exert a great power when it revolves rapidly, even though the principle may not be the most effectively applied. Captain Ericsson tried his propeller on a small scale in the Thames: the boat was forty feet long, eight feet in breadth, and it drew three feet water, and had two propellers, each of five feet three inches in diameter. The power of the propeller was well developed in this boat; its effect was quite satisfactory. This encouraged him to invite the lords of the Admiralty, and the surveyor of the Navy, to witness the performance of the boat; but although the power exerted by the screw was unquestionable, yet the surveyor came immediately under the controlling power of prejudice against it, and the board of Admiralty took no further interest in the propeller, after having attended the experiment.

Mr. Francis B. Ogden, formerly the American consul at Liverpool, had assisted captain Ericsson to bring out his plan of propulsion in the experimental boat, which was called the *Francis B. Ogden;* and now, under the pressure of discouragement, with which the British government, and the civil engineers of the country generally, so far as his plan became known, treated him, he was further relieved by the friendly sympathy and aid of another citizen of the United States.

The attention of captain Robert F. Stockton of the United States' navy was drawn to the propeller in the experimental boat. He immediately perceived its superiority to paddle-wheels, and ordered two iron boats to be built, and fitted with steam machinery and the screw propeller, upon captain Ericsson's plan. These two vessels were intended to be sent to America; and from this event resulted the introduction of the Ericsson propeller into the United States of America, where it gained, and has supported, a high reputation among the commercial interests of that country. Captain

Stockton looked forward with confidence to the application of this propeller to war steamers; and, under the encouragement of that prospect, captain Ericsson gave up his engagements in London, and went to America, where he saw, at length, his propeller applied on a large scale in the American navy. The following particulars of the steam-frigate *Princeton*, belonging to the United States, and fitted with captain Ericsson's propeller, were obtained in America by a British naval officer: length of ship, 164 feet; breadth of beam, 30 feet; depth of hold, 22 feet 6 inches; draught of water, 17 feet 6 inches; burthen about 700 tons. The propeller is 14 feet in diameter, with 6 blades, and makes from 32 to 36 revolutions per minute. The engines are about 400 horse-power; the speed is stated to be about 14 miles per hour.

The decided success which had marked the course of Mr. Smith's experiments led to the formation of a company called the "Ship Propeller Company," whose first object was to determine the adaptation of the screw, as a propeller, on a larger scale; but as soon as the object was known, the scheme was loudly decried by almost all professional men and manufacturing engineers, insomuch that it was found difficult to engage an engineer to construct the engine and machinery in so unpopular an enterprise. At length Messrs. Rennie, who had witnessed some of the experiments with the small vessel, not only undertook to build the engine, &c., but became personally interested to a considerable extent in the success of the object.

For the purpose of making a more conclusive experiment, a vessel was built in 1838, of the following dimensions: extreme length, 125 feet; length between the perpendiculars, 106 feet 8 inches; extreme breadth, 21 feet 10 inches; depth in hold, 13 feet; mean draught of water, 9 feet 6 inches; burthen, 237 tons; power of engines, 80 horses, nominally; but which experience proved did not exceed 66. The vessel was named the *Archimedes*. Her propeller was at first a single-threaded screw, forming one complete turn upon its axis, being 5 feet 9 inches in diameter, and 8 feet pitch; but this was subsequently removed, and its place supplied by a double-threaded screw, each thread forming half a turn upon the axis; and the entire propeller was so fixed that it could be disconnected and taken into the vessel, to remove the obstruction it would have presented to the sailing of the vessel, when the wind was favourable to the use of canvas.

Several trials of the power of the screw-propeller were made in the river Thames, and in the British Channel, in the month of April, 1840, when the speed of the *Archimedes* was tried against that of the *Ariel*, *Beaver*, and *Swallow*, mail steam-packets. The results varied as to the comparative velocities of the vessels, and on the 28th of April captain Chappell, R.N., who had been appointed by the government "to examine into, and to report upon, the merits of Mr. Smith's patent screw-propeller, in use on board the *Archimedes*, as compared with the ordinary paddle-wheels applied to her Majesty's mail packets on the Dover station," undertook the superintendence of the experiments.

The public press of that time states, that in her passage down the Thames on the 3rd of May, she performed the passage from London to Gravesend in one hour and forty minutes, and from Gravesend to the Nore in one hour and a-half; that she passed through the water at the rate of ten miles an hour, and that her speed with the tide, but against the wind, was thirteen miles an hour.

Captain Chappell says, in his first report, "On my arrival at Dover I made arrangements with commander Boteler, by which the *Widgeon*, mail steam-packet, was placed at my disposal. The following statement shows the comparative size, power, and immersion of the two vessels:

Names.	Tonnage.	Diameter of Cylinders.	Length of Stroke.	Mean Draught of Water.
Widgeon . .	162	39 inches.	3 feet 1 inch.	7 feet 3 inches.
Archimedes .	237	37 "	3 feet.	9 feet 4 inches.

"The *Widgeon* is the fastest packet on the Dover station: she has 10 horses power more, and 75 tons burthen less than the *Archimedes*, and the mean draught of water of the former is 2 feet 1 inch less than that of the latter."

Several experiments were then made by the two steam-vessels in crossing the Channel from Dover to Calais, and back; and with reference to them captain Chappell remarks,—"these trials clearly prove that the speed of the *Archimedes* is slightly inferior to that of the *Widgeon* in light airs and calms, and in smooth water; but as the steam power of the former is ten horses less, and her burthen seventy-five tons more than the *Widgeon*, it is evident that in these vessels the propelling power of the screw is equal, if not superior, to that of the ordinary paddle-wheel. In this respect, therefore, Mr. Smith's invention may be considered completely successful."

The following tabular statement will show the comparative advantages of power, burthen, and resistance, by which each of the packets was superior to the *Archimedes*:

Names.	Horse Power.	Area of Midship Section.	Burthen in Tons.	Relation of Power to	
				Area of Midship Section in feet.	Tonnage.
Archimedes . .	80	143	237	as 1 : 1.789	as 1 : 2·962
Ariel	60	95	152	1 : 1·583	1 : 2·53
Beaver . . .	62	84	128	1 : 1·355	1 : 2·097
Swallow . . .	70	84	133	1 : 1·2	1 : 1·9
Widgeon . . .	90	95	162	1 : 1·05	1 : 1·8

Thus it appears that, in both respects of comparison, the advantage was on the side of all the steam-packets propelled by paddle-wheels, and, in the highest degree, of the *Widgeon*.

The *Archimedes* was afterwards placed at the disposal of captain Chappell, with the view to test the adaptation of the screw-propeller to the various circumstances which may arise in navigating the open sea, by making a voyage round the coast of England and Scotland. This voyage was made the occasion of presenting opportunities for the fullest investigation by scientific and practical engineers, and by naval officers and other nautical men, at all the ports round the coast. And many testimonials were elicited in favour of the invention, and of its adaptation to general use, decidedly in preference to paddle-wheels.

In the various trials of speed which were made round the coast, the powers of the vessel and her machinery were tried alone, unaccompanied by any competitor; and the average rate of the whole distance of 2006 nautical miles which the vessel ran, was accomplished at the average rate of 7·336 miles per hour, whilst, under very favourable circumstances, she ran a distance of thirty miles at the rate of 10·9 miles per hour.

When the *Archimedes* had completed her passage round Great Britain, she proceeded immediately from Plymouth to Oporto, and performed the passage in sixty-nine hours, without any occasion having presented itself, during that time, to stop the engines. This was the shortest passage that any steam-vessel had ever made between those ports.

The proofs of the screw's superiority were established, as the trials to which it was put developed its capabilities: but, generally, the invention was discouraged. Besides those who saw what it could achieve, perhaps there were very few that were willing to relinquish a partiality for what they knew to be effective. And engineers generally were reluctant to allow the claims of an invention which would interfere largely with the profits of their capital invested in machinery and patterns constructed on the old principle. A striking instance of prevailing disinclination to the screw-propeller, was shown on the issue of a new edition of the Encyclopædia Britannica, in which the article on steam navigation contained no notice whatever of the subject.

The government had appointed Mr. Lloyd, the chief engineer, with captain Chappell, officers whose suitableness to investigate the merits of the invention and its general applicability, were, perhaps, not to be exceeded by any in the naval service; and their testimony in favour of the screw was supported by that of many other naval officers, of eminent engineers, and of other gentlemen fully competent to appreciate its claims. The surveyor of the navy had, however, conceived, and he always maintained, a very strong objection to the screw-propeller,—an objection which was always much more associated with imaginary difficulties, than with facts; but its influence at the Admiralty was unquestionable. In this state of things the government were particularly cautious in acting upon a judgment which had been formed upon facts developed in the performances of the *Archimedes*.

Within a limited sphere a decided confidence had been produced in the screw-propeller by the performances of the *Archimedes*. And in the early part of 1841, a small steam-packet, called the *Princess Royal*, was built in the north of England, for a company at Brighton. Her dimensions were as follow: length of keel, 81 feet; breadth of beam, 17½ feet; depth in the hold, 10 feet; draught of water, 6½ feet; register tonnage, 101 tons. She was fitted with two engines of 23 horse-power each, and with a screw-propeller of 5 feet in diameter and 6 feet pitch. Her speed was about eight knots an hour; she made the passage from Newcastle in 48½ hours, and arrived at Brighton on the 8th of June. She was fitted up for pleasure excursions, from Brighton to places within a convenient distance, upon the south coast; and her first employment was to carry a party to Arundel, on the 9th of June. In the autumnal gales of the same year, that little vessel exhibited proofs of superior power as a tug. The "Morning Chronicle" of the 27th October, 1841, says, that during one of those gales she towed two large brigs at one time out of Shoreham harbour, "against the wind, and a tide setting in at the rate of four miles an hour. She lately took out a brig when it was deemed unsafe, by almost every one present, to make the attempt, owing to the heavy sea that was then rolling into the harbour; the *Princess*, however, accomplished her task nobly. To give some notion of the violence of the gale, the brig, in setting reefed topsails, carried away both topmasts, immediately after the steamer had cast off, and was obliged to run for Newhaven." These and other performances of the screw were calculated to produce public confidence in that form of propeller, and, even in its infancy, to render it popular. The committee of management of the company in question, in a letter to the directors of the Ship-propeller company, who had purchased the patent of Mr. Smith, said, "We feel ourselves bound to express our entire satisfaction with the success which has attended the application of your patent to our vessel, the *Princess Royal*, steam-boat, which, in everything connected with the machinery and its arrangements, her speed, and the facility with which she is managed, has far exceeded our expectations."

The *Bedlington*, of about 270 tons, and 60 horse-power, was built at South Shields, in 1842, and fitted with a screw-propeller; and the *Novelty*, of London, of 300 tons, and 25 horse power: this appears to have been the first vessel to which the screw was applied as an auxiliary propeller. The *Bee*, of 30 tons, and 10 horse-power, was built at Chatham for the instruction in the management of steamers, of officers at the Naval College at Portsmouth, and was fitted with a screw as well as paddle-wheels; and the *Rattler* was ordered to be adapted to the reception of the screw. The determination had also been taken to employ it instead of paddle-wheels in propelling the *Great Britain*.

Next came the *Great Northern*, laid down in 1840, and built by captain Coppin, at Derry, in Ireland: she was launched in July, 1842. Her principal dimensions were,—length over all, 247 feet; between the perpendiculars, 221 feet; breadth, 37 feet; depth in hold, 26 feet; draught of water, 18 feet; tonnage, builders' measurement, 1750 tons; engines, by Messrs. Miller and Ravenhill, 325 horse-power. Her screw was 12 feet in diameter, and 14 feet pitch; being, however, only 7 feet in length. Apart from the novel mode of propulsion having given this ship a distinction, she possessed the local interest, as it was stated at the time, of being the largest ship ever built in Ireland.

At length the *Rattler*, of 888 tons, and 200 horse-power engines, built upon the lines of the *Alecto*, *Polyphemus*, and *Prometheus*, was adapted by an additional length aft, for the reception of the screw-propeller; and its capabilities were put to the test. The course of experiments made in the *Rattler* led to important results, as screws in considerable variety were tried, and the grounds of preference were developed in the performances of the vessel. The trials were begun with the screw in the state in which it had been used in the *Archimedes*, consisting of two half turns of the blade upon its axis. On the 30th October, 1843, such a screw of 9 feet diameter, 11 feet pitch, and 5 feet 6 inches in length, was tried in the *Rattler*; but the experiment seems not to have been made with enough care to supply results which might be used in comparison. In November, some further experiments were made with a screw of the same diameter and pitch, reduced in length—first to 4 feet 3 inches, and then to 3 feet; but as these also were merely preliminary trials, perhaps no stress ought to be laid on them; we will, therefore, only remark, that with the diminished length of screw, she gained in speed a little more than half a knot an hour, with about the same slip. Circumstances, varying but very little, might cause so much difference, apart from the alteration of the screw.

In February, 1844, the screw, three feet long, was tried again; the speed of the engine was increased by 1·4 stroke per minute (the revolutions of the screw being 106 in a minute), that of the screw through the water 0·868, and that of the vessel 0·375 knot per hour. Hence the slip became greater as the speed of the engine increased. In March, the trial of the same form of screw was repeated; the revolutions of the screw diminished by 8 in a minute; the speed of the vessel was about the same, the slip having diminished from 24·44 to 12·9 per cent. Reduced in length to two feet, the revolutions of the screw increased to 100·6 per minute, and the slip became 13·4 per cent. With a further diminution in its length, of six inches, its revolutions became 102·1 in a minute, and its slip 12·24 per cent. When the length of the screw was only 1 foot 3 inches, it revolved 103·6 times in a minute, and its slip was only 10·42 per cent., in a calm.

Mr. Smith's screw with three blades was tried at different lengths, its diameter being 9, and pitch 11 feet. The length being at first 2 feet 3 inches, its revolutions per minute were 94·3, and slip 33 per cent. Reduced in length to 1 foot 8½ inches, and making 92 revolutions per minute, its slip was diminished to 18·8 per cent., in a fresh wind abeam. This was the smallest length to which the screw was reduced; in this state, with 108·4 revolutions per minute, the slip was 16 per cent.; and with 100·8 revolutions, the slip was 12 per cent., in a fresh wind.

Mr. Woodcroft's propeller was the subject of several experiments. First, his four-threaded screw, 9 feet in diameter, 1 foot 7 inches in length, and the pitch increasing from 11 feet forwards to 11·55 feet aft; making 104·3 revolutions in a minute, its slip was 27·77 per cent., with the wind abeam; and when the screw made 95·9 revolutions, the slip was reduced to 23·56 per cent., with a light wind abeam. His two-threaded screw was of the same diameter, length, and pitch; and with 107·5 revolutions in a minute, its slip was 27·76 per cent., with a very light wind.

Steinman's, or Blaxland's propeller, patented by Blaxland in November 1840, was tried. The diameter was 10 feet, and pitch 11 feet 6 inches; when its revolutions were 104·2 in a minute, the slip was 19·2 per cent.; and when they were 100·94 in a minute, after some alteration had been made in the screw, the slip was 15·73 per cent.

The last screw-propeller to be noticed in these experiments is Sutherland's two-threaded screw, 8 feet 2 inches in diameter, 26 feet pitch, and 8 feet in length. When its revolutions were 69·9 in a minute, the slip was 53·5 per cent.; and when they were 57 in a minute it was 55 per cent.

Nothing needs to be added to the facts developed in the experiments, to prove that Mr. Smith's propeller, formed of two small sections of the blade of the screw, was better than any other form that was tried; for it produced the greatest speed in the ship, and was subject to the least amount of slip. It was important that the screw should consist of only two sections, and that these should be small. One consideration in regard to its general use was, a convenience in raising it from its working position in the run, when sail only was required. In the condition of the screw, which was shown to be preferable as to both speed and slip, it was found quite convenient to make it travel in a vertical trunk, formed immediately over the aperture in the dead-wood for the working of the screw. This arrangement was then adopted, and it is now deemed so important in the navy as never to be dispensed with.

The relative efficacy of different forms of screw having been determined, and Mr. Smith's propeller, consisting of two small sections of a helix, having been selected as the best form, the next trial to which it was necessary to put it, was that in which its propelling power would be compared with paddle-wheels. It might be enough to state a few of the trials made with the *Rattler* and the *Alecto*, for they presented results which ought to be satisfactory. In some of the preliminary trials, the relative power of the screw and of the paddle-wheels was doubtful. There was great emulation on board of both vessels; for each captain was a decided advocate of the description of propeller whose power he was charged to develop; but the competition soon took a decided character, and the following extracts from a letter, written by Mr. F. P. Smith, on the 31st of March, 1845, states some of the facts, in different conditions of the weather: "*Rattler* has redeemed her lost laurels, both to-day and yesterday; during a perfect calm we ran from the Little Nore to Yarmouth-roads (80 miles), beating *Alecto* 23½ minutes, although, in consequence of so short a supply of steam, we were compelled to work the second grade of expansion throughout the day, and the engines making only 23½ to 24 strokes per minute. On *Alecto's* arriving in Yarmouth-roads, we started again, and both ships set all sail to a moderate breeze, and continued running till off Cromer light; *Rattler* beating in 24 miles, by 13 minutes. From the bad appearances of the weather, it was deemed proper to anchor for the night, during which it blew a complete gale from the N.N.W., and continued throughout the day, affording the very opportunity we were seeking for trying *Rattler's* powers at a head sea. On starting, of course all was anxiety; but a few minutes were sufficient to show that we were to win the race: the distance run, being about 60 miles, was won by *Rattler*, passing the Spurn light 40 minutes before her competitor. We have taken dynamometer and indicator diagrams throughout the day; the very *lowest* pressure exhibited when the *screw was out of water* (as folks say) is 3 [illegible] ranging up to 64 lbs. on Salter's balance. I may say that on one occasion we lost steam, which brought *Alecto* alongside. This was at 10 o'clock; and it was from this time till we anchored that the 40 minutes were gained, although prior to that, when the sea was the roughest, we gained more than half a mile on *Alecto* in the first hour, she having got the start of us in that distance. The 59 miles were done in 7½ hours, tide principally against us. As you may suppose, the Alectos are all taken aback: captains Austin and Hoseason are now on board us, and both say they had not the slightest idea that we should ever have held way with them."

So far the trials related to speed: but it was deemed advisable to put the screw-propeller to severer trials against the paddle-wheels, and the following extract from a report made officially to the Admiralty, and afterwards laid, with other papers, on the table of the House of Commons, will show their character and the results.

"Thursday, 3rd April, 1845.

" A.M.	9h.	40′	0″	took *Alecto* in tow with her floats off.	
A.M.	10	10	8	set patent log.	
A.M.	11	10	8	patent log showed rate of towing . .	$7\frac{1}{10}$
P.M.	4	0	0	*Alecto* took *Rattler* in tow.	
P.M.	4	15	0	set patent log.	
P.M.	5	15	0	patent log showed rate of towing . .	$5\frac{17}{10}$
				In favour of *Rattler*	$1\frac{4}{10}$

" P.M. 5 30 0 lashed stern to stern, allowing *Alecto* to get her speed, when *Rattler* turned ahead, and succeeded in towing *Alecto*, in spite of her efforts to the contrary, by both ships' logs, $2\frac{1}{2}$ knots good, and by patent log $2\frac{8}{10}$ knots.

" *Experiments.*

" Stopped with a fresh wind astern, going 9·5 knots, and obtained sternway in 2′ 8″.

" Stopped in a calm with stern way, 7·5 knots, in 1′ 33″.

" Full speed, helm hard down, 1st circle 5′ 39″; 2nd circle 5′ 31″. Came round 16 points after engines were stopped.

" Helm hard down, from no way; setting the engines going she described the circle 5′ 17″."

From the alternate efforts of the two steam-vessels in towing each other,—namely, *Rattler* towing *Alecto* $7\frac{1}{20}$, and *Alecto* towing *Rattler* $5\frac{17}{20}$, the following result is drawn:—As $7\frac{1}{20} : 5\frac{17}{20} :: 100 : 83$. And $100 - 83 = 17$ per cent., the superiority of the *Rattler* with the screw, to the *Alecto* with paddle-wheels.

The question was now decided; and apart from a judgment which had been formed before the two methods of propulsion were thus fairly tried together, an also from a consideration of the tenacity with which opinions are held by ns of some characters after having been once received, it is difficult to ive on what ground the paddle-wheels could be preferred by persons who had no *interest* to bias their judgment. The facts ascertained during these experiments were not, however, wholly unavailing at the Admiralty. It had become evident that the desideratum which would unite the advantages of steam-power with the effectiveness of broadside armament was the screw-propeller; for the low position at which the machinery and boilers may be advantageously placed, diminishes the hazards of injury; and the very small space occupied by the screw is a further consideration in favour of its use.

Before experience arrived at that point, very definite opinions had been formed of the advantages that must be realised in using the screw-propeller, rather than paddle-wheels, in war steamers. Captain Chappell had said, "In vessels of war the screw-propeller admits of the whole machinery being kept below the water-line; of the ship being ordinarily used with sails only, but of being converted into a steamer in a few minutes; or, as the action of the screw is equal, whatever may be the heel or inclination of the ship, the screw will allow of using both sails and steam when required. The propelling apparatus is placed wholly out of reach of injury from shot, the falling of masts or collision with other vessels; the whole broadside battery is left unobstructed; and should every mast be shot away, the propeller might still enable a ship to maintain an efficient fighting position, to follow an enemy if required, or to convey the vessel safely into port, however crippled in condition." *

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* Reports relative to Smith's Patent Screw Propeller, as used on board the *Archimedes*, steam-vessel, &c. By Captain Edward Chappell, R.N.; London, James Ridgway, 1840."

This concise statement includes almost all that needs to be said on the superiority of the screw to paddle-wheels for the purposes of war; but the British government was too cautious to proceed at once on the intelligent view of one clearly defined and amply developed fact. Not so that of France: "The French government are fitting three vessels to be impelled by the same agency," (the screw-propeller) wrote Mr. Elijah Galloway in 1842. Lieutenant Labrousse of the French navy presented to his government a plan for bringing the screw-propeller into use, and afterwards gave publicity to it through the press, in 1843. In the mean time, extracts from his plan were inserted in a work of considerable merit.* The following quotation will best show how later experience was so long ago anticipated:

"*Ships of War.*—The use of the screw, as a means of propulsion, is far from diminishing a ship's sailing qualities; it is, on the contrary, capable of adding to the certainties of navigation, and the advantages of its application to ships of the line become so incontestable and so striking, even to persons not acquainted with steam navigation, that it seems useless to enumerate them. Let us imagine two ships together, one using the screw and the other sail, what inequality will there not be between these two ships, one of which will be able to move about the other in all directions, with at least double the common velocity of a ship (at the time and with the sails used in action), without anything being able to alter her moving power, whilst the other can move only in certain directions by the help of sails which are wholly exposed to the enemy's shot? Suppose the superiority should remain with the last (which yet seems impossible), what advantage could she make of it, since the screw-ship could always withdraw at a certain time from the shot of her conqueror, unable to follow?

"Thus, then, however great the inconveniences resulting from the application of the screw to ships of the line may be, its advantages for fighting are so incontestable that one could not hesitate at adopting it; for the advantage will necessarily remain with the power which first opposes such ships to ordinary ships.

"The principal question is, to place the instrument out of the reach of shot, and it is on this account that the wheel system cannot be compared, in this case, with the screw system.

"It follows, from inquiries that I have made in this respect, that in adopting for ships an engine of the power of 1000 horses, even of low pressure, the whole system may be placed entirely below the water. Besides, the screw, scarcely susceptible of injury, is completely immersed and protected by the stern of the ship, which conceals it."

At the same time, the use of auxiliary steam power and of the screw-propeller was considered necessary to ships of the line. For, after quoting from a note addressed in 1840 to the Inspector-general of the *Génie Maritime*, on the employment of auxiliary steam power and paddle-wheels to the *Suffren*, a 90-gun ship, M. Campaignac says, "If circumstances had permitted of carrying this proposal into effect, by applying common steam machinery to a ship of the line, as a secondary or occasional means of navigation, the question of blending the sailing navy and the steam navy for naval war would now be far advanced, and ready to improve by the progress made in locomotion by steam, both in the system of construction of marine engines, and in the substitution of the Archimedean screw for paddle-wheels, as a means of propulsion. It is said we mean to try captain Smith's screw in a third class frigate of war. It seems to us that this propeller would be situated more favourably at the sides of the ship, and towards the actual position of the paddle-wheels, than in the solid abaft near the stern-post."*

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* De l'État Actuel de la Navigation par la Vapeur, &c. Par A. Campaignac; Paris, 1842.

The advantages of the screw having been thus clearly estimated, the French Government began at once to introduce its use: but the present state of their steam navy shows that they have not pursued the improvement with the uniform energy of which it is worthy.

The suggestion which was offered, for the employment of steam-engines and a screw-propeller in the *Suffren*, was not entertained by the French government. But the object at which that suggestion aimed has since been appreciated; and the French are now carrying into effect a more majestic if not a more useful plan for a steam navy, than we are. The *Austerlitz* of 100 guns, laid down at Cherbourg in 1832, has been selected, to be fitted with steam-engines of 650 horse-power and a screw-propeller. Her dimensions are,—length on the water-line, 204 feet 3½ inches; breadth moulded, 53 feet 2 inches; depth, from the upper part of the keel to the load-water line, 23 feet 1½ inch; and displacement, 4374·73 tons. This ship was designed by a committee composed of Messrs. Sané, Rolland, Laird, Tupinier, and de Lamoriniere. A second line-of-battle ship, upon which they purpose to make trial of the screw-propeller, is the *Napoléon*, which has been recently launched, and is so called in honour of the President of the French Republic. Some time after the revolution, this ship was called *Le* 24 *Fevrier*, in commemoration of that event. She was laid down at Toulon in 1847, and is to be fitted with engines of 900-horse power. Her principal dimensions are,—length on the water-line, 233 feet 11 inches; breadth, moulded, 53 feet 2½ inches; depth in hold, from the water-line to the upper part of the keel, 23 feet 5½ inches; and displacement, 4973·46 tons. The 24 *Fevrier* was designed by M. Dupuy de Lôme. The armament intended for this ship is as follows: for the gun-deck four shell guns, of 8·66 inches calibre, and 32 long 30-pounders; for the upper deck four shell guns of the same calibre, and 32 short 30-pounders; and for the quarter deck and forecastle, four shell guns, of 6·3 inches calibre, and fourteen 30-pounder carronades. It has been in contemplation to apply steam-engines of 450-horse power, and the screw-propeller to another ship of the line, the *Nestor*, a fourth-rate, of 74 guns. Without venturing an opinion of the probable result of these projects, it may be observed that they indicate, in the event of its being satisfactory, the course which the French government is likely to pursue, in the progress of developing a steam navy.

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* De l'Etat Actuel de la Navigation par la Vapeur, &c. Par A. Campaignac.

When the screw-propeller was first tried in the navy, it was not known what would be its best form; it was not supposed by any body that the small section at present used would be enough: it might, for any thing that was then decided, be a screw of one complete turn upon its axis. Upon the supposition that this might be necessary, the *Rattler* was lengthened by the stern sufficiently for a long aperture. Nor had experiment shown that the form of the tuck was an important element, as to the effect of the screw; but in lengthening the *Rattler*, the run at the fore part of the aperture was constructed of such a degree of fineness, as to be the most favourable to the efficacy of the screw. The correctness of form in this case was accidental; and as no one in the service who was called upon by the Admiralty to form plans for other steam-vessels to receive the screw, considered that a fine run was material; and as there were reasons why the after part of the vessel should have as much support in the water as could be given to it, every vessel constructed to be propelled by the screw, before the summer of 1846, was designed with a full tuck.

In March, 1846, Mr. Lloyd, then chief engineer at Woolwich, addressed a letter to the commodore-superintendent of that dock-yard, suggesting the consideration that the surface of the aperture before the screw might have something to do with the effect of the screw. He said, "In making the arrangements for the apertures of the screw-propellers, it sometimes occurs, owing to the form of the vessels near the water-line, and immediately below the unshipping trunks, that the fore side of the aperture is terminated by a surface nearly flat, having a considerable breadth athwart-ships.

"To what extent the efficient action of the propeller would be injured when acting under such circumstances, and whether the obstructions to the vessel's motion through the water which such a surface seems calculated to produce would sensibly diminish her speed, are questions of great importance, which no one, I believe, at present can determine, as the necessary facts for doing so can be obtained by experiment alone.

"A trial of the screw-ships now in progress will not, in my opinion, throw much light on the subject, as it will be impossible to say whether the superiority which one may possess over another can justly be attributed to the absence of the obstruction before referred to, or her superior form.

"I take the liberty, therefore, of suggesting whether it may not be desirable to fix upon the after part of the *Dwarf* some temporary pieces of wood or iron, so as to alter her lines in the neighbourhood of the screw aperture, with a view of determining whether any and what effect in her speed would be thereby produced. This would be attended with considerable expense; but I think the advantage of determining so important a question would probably outweigh it." *

The board of Admiralty gave direction, in the month of April, for the proposed experiment to be made. The run of the vessel was filled out to produce a transverse surface from the upper part of the aperture down to the centre of the screw, to a breadth equal to the diameter of the propeller. Without waiting till it might be convenient to vary the experiments, Mr. Lloyd said, "I deem it proper to express my opinion, from what I have done, that such forms are exceedingly prejudicial to velocity, and should not be adopted in her Majesty's vessels, the rate of the *Dwarf* having been reduced from nearly nine knots to about three and a quarter, by filling out the vessel at the upper part of the aperture to a breadth about equal to the diameter of the screw, and leaving unaltered the part of the aperture from the centre of the screw to the keel." This report was made in November of the same year.

The immediate consequence of the experiment and report in question was, that the screw steam-vessels then in the course of building, and which were not finished, or nearly finished, were altered; for although the experiment on the *Dwarf* did not determine what form of the run was right, it showed the extreme of what was wrong, and drew to the subject the attention of all who were concerned in the building of steam-vessels for the screw.

At that time a considerable number of screw steam-vessels were in different stages of building. The decision was at once taken to arrest the progress of those which were not advanced nearly to completion; for they had all been constructed with a tuck more or less full; and, therefore, all needed alteration. It is true that the experiment made on the *Dwarf* did not show what this alteration should be; it only showed an almost extreme case of malformation, with reference to the working of the screw. On the other hand, the fineness of the run in both the *Rattler* and *Dwarf* was evidently favourable to speed. The important questions to be decided were, therefore, how much of the buoyancy of the stern must be surrendered by increasing the fineness of the run, and what was the limit of fineness which would be sufficient to allow the water to flow into the neighbourhood of the screw with a rapidity which would supply a dense enough mass of water for the screw to exert all its power advantageously in. In a state of science that has not defined the curve which would determine this outline, the most simple and certain way to ascertain that form would have been by approximation. This was not exactly the course which was taken; but the constructors of the several screw steam-vessels yet unfinished were required to submit proposals for such modification of the after part of the vessels respectively as they deemed suited to produce the improvement required. Some constructors rather hastily inferred, that all screw-ships must have a fine run, in order to a good effect, irrespectively of the speed which the ship might be required to attain. But the experiment did not appear to the author to lead necessarily to such an inference; and it seemed to him wise to proceed cautiously, with the view to arrive at the true conditions of form required for general service, at the least expense. Some time before this, the question of converting several line-of-battle ships into steam guard-ships had been brought under the consideration of the Board of Admiralty. The recommendation was made by a commission, appointed in 1844 to inquire into the state of the coast defences. The members of this commission were, captain sir Thomas Hastings, R.N.; colonel sir George Hoste, R.E.; and colonel Mercer, R.A. The principal object of their appointment was to investigate the state of defence of the naval arsenals at that time, and to suggest such changes as would give them protection against any sudden attack. The means of defence of the naval stations were most deficient, as were also those of the line of coast generally; and it was clearly seen that the common guard-ships would not be able to repel an attack made by steamers,—the means by which it was supposed aggression would be attempted in future war. In addition, therefore, to the improved military defences which they recommended, they proposed that the government should convert some of the smaller two-decked ships and frigates into steam-ships, to constitute a system of naval protection, suited to the threatened emergency, of the coast and harbours of the country. The subject was taken up with energy by the right honourable Henry Thomas Lowry Corry, who was then at the admiralty; the feasibleness of the project was considered and determined; and, after different schemes had been considered, it was resolved to fix the propeller in the dead wood, in accordance with the plan which had been patented by Mr. Francis Petit Smith. With respect to some of these ships, the proposal to increase the length, in order to produce a fine run for the screw to work in, was entertained by the Admiralty: the *Hogue* and the *Blenheim* were accordingly lengthened. The author was consulted by the Admiralty on this subject; and considering that there were not sufficient data for a general conclusion, as to the form which should be given to the run; and also, that as a very moderate speed was required in these ships, it would be wise to incur, in the first instance, no expense beyond what was inevitable in adapting the ship to the reception of the engines and the screw: to subject only one of the ships to the alteration, until the effect of that should be tried; and then at every successive step in this direction, to proceed on certain data. It was considered that by pursuing such a course, two important objects would be attained: that the expense to be incurred, of converting the several line-of-battle ships and frigates into screw-ships, would be materially less than it would if the alteration of each ship were an experiment; and also, that if it were found necessary to give a fine run to any of these ships, the experience which would be gained would be more definite, as to the effect which would be attributable to the form of the run. This recommendation was entertained with reference to the *Ajax*. No addition was therefore made to the length of that ship: a hole was cut in the dead-wood of the run for the reception of the screw, and a trunk was constructed for the propeller. The fulness of the tuck remained: and fig. 4 shows the form of half the transverse section forming the fore part of the aperture; and fig. 5 shows the form of a horizontal section, *a c d*, of the after part of the body immediately before the aperture and at its upper part,—*a c* in fig. 5 corresponding with *a c* in fig. 4. The Admiralty did not wait to obtain one well-defined experiment, before they ordered the machinery to be placed in two of the other ships, the *Blenheim* and the *Hogue*. These two ships were lengthened to produce different degrees of fineness in the run. The results of trials of the *Ajax* and the *Blenheim* have proved that, for the speed which is required of that class of ships, a fine run is not needed. The engines of both ships are of the same power; the screws were of the same diameter, and the pitch differed so little, that the angle of the *Blenheim's* screw was greater than the angle of that of the *Ajax* by less than half a degree. Under these conditions, the speed of the *Ajax* was 6.46 knots an hour, with a slip of 18.54 per cent. of the speed due to the revolutions of the screw; and the speed of the *Blenheim* was 5.74 knots with a slip of 31.97 per cent. of the speed due to the revolutions of her screw. The screw of the *Ajax* having been changed, the same diameter being retained, and the angle of the blade having been reduced from 21° 12′ 20″ to 19° 37′ 30″, her speed with a less power exerted than in the previous experiment, or than in the experiment with the *Blenheim*, was 7.063 knots an hour, with a slip of 16.18 per cent. on the speed due to the revolutions of the screw. These facts show clearly that, at a speed of seven or eight nautical miles an hour, a full tuck is not disadvantageous to the effect of the screw; and that, therefore, in this class of ships, the fulness of the stern may be retained.

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* Parliamentary paper, No. 555, session 1848.

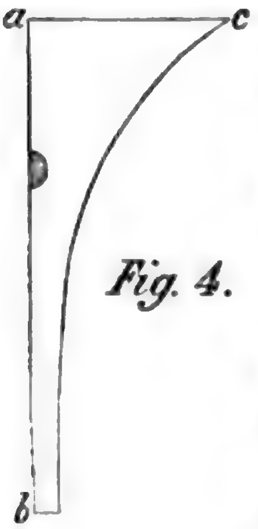

Fig. 4.

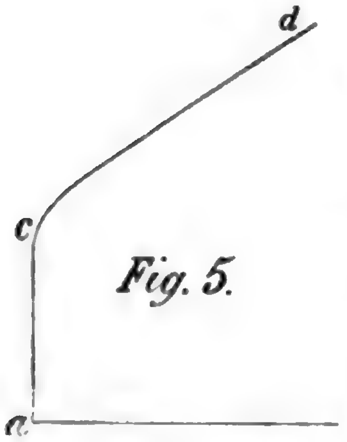

Fig. 5.

The same fact was shown, to some extent, in the *Arrogant*; for, with a degree of fulness in the run of which some very experienced men disapproved, and with a screw 15 feet 6 inches in diameter, and whose angle is 17° 7′ 20″, she has attained a degree of speed slightly in excess of that which is due to the revolutions of the screw. Her speed was 8.26 knots;

it is therefore clear, that when the speed under steam is not required to be greater than that—and this is generally the case when the steam power is only auxiliary—a fine run is not necessary.

The same principle does not apply to screw ships of full steam power. The *Dauntless* steam frigate (*Plate* 45 *a*), was the first of her class that was constructed; her construction was therefore an experiment. The order for the design, and the execution of it, were in the year 1844, when England was alarmed lest the safety of its shores might soon have to be identified with an efficient *steam navy*. So far the need of the country was perceived. But there had been nothing in experience to show what should be the conditions which would fulfil the intentions of the government, in introducing into the navy a class of ships with peculiarities of so great magnitude and importance. It was clear that the quantity of displacement must be extraordinary in relation to the armament. The chief problem to be solved in such an experiment, was to produce the best form, having such displacement, carrying the ports at a sufficient height from the water, and with enough stability for the sail required by such a ship. As paddle-wheel steamers could not show in what manner these results could be obtained, the plan must assume some bold features of originality which it is not common to hazard in naval construction.

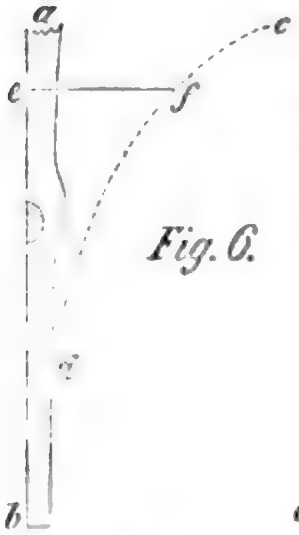

Fig. 6.

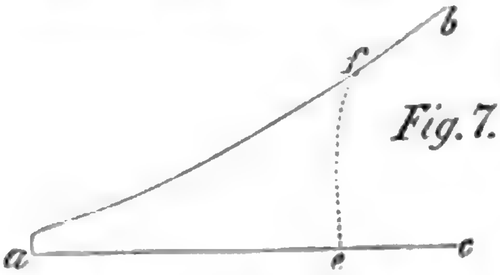

Fig. 7.

It has been observed at pp. 356-7, that the conditions of the after part of the ship required for the screw-propeller were not determined at that time, and the tuck was made too full. Figure 6 represents the form of half the fore part of the aperture, and *b f*, fig. 7, the form of the water-line, and *e f* the abrupt termination transversely at the upper part of the aperture.

The trial of the ship with such an aperture, showed the necessity of alteration. She was therefore lengthened by an addition of 10 feet to the after body; and fig. 7 shows the addition of the horizontal section at the upper part of the aperture, *a e f* representing the part added to produce a fineness of the form immediately before the aperture. With such additional length, her principal dimensions are as follow:—length between the perpendiculars, 218 feet 1 inch; extreme breadth, 39 feet 9 inches; depth in hold, 26 feet; load mean draught of water, 17 feet 3 inches; load displacement, 2432.8 tons; and area of greatest transverse section at this immersion, 559 square feet.

The effect of the alteration has been perfectly satisfactory. The speed of the engines was increased, from a mean of 24⅔ strokes in a minute, with the original form of the ship, to a mean of 30 strokes in a minute with the alteration; and the slip of the screw was diminished from 25.69 per cent.

THE DAUNTLESS,
Steam Frigate with Screw Propeller.

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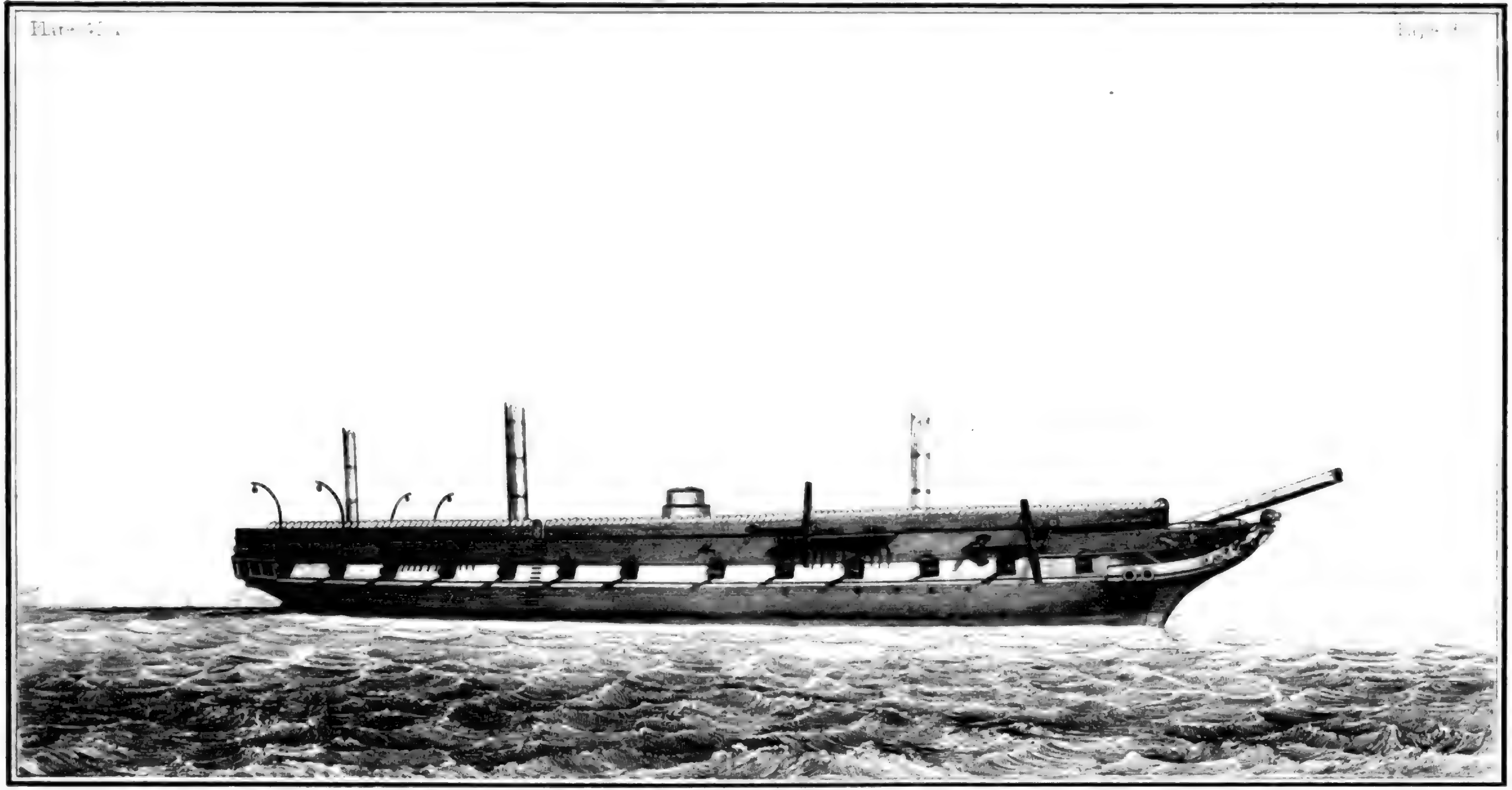

to 14.93 per cent. of the speed due to the number of its revolutions. This remaining amount of slip is large in comparison with that of some other experiments which have given good results. But as the angle of the screw was 21° 22′ 15″, and as the loss by slip diminishes as the angle of the screw is diminished, there is little doubt that all that is needed to the highest development of the effect of the screw depends on the correctness of its angle, and the capability of the engines and their gearing, to give the required speed to the screw.

The measure of success of this ship, as exhibiting a new class, can be determined only by experiment; it is, however, in the course of development. But, as the masting which the author proposed as, according to his judgment, the best suited to the ship, was not approved, and as smaller masting has been substituted, the sailing qualities of the ship cannot yet be fully known. There is little doubt, that in some points of detail, improvements might be made in the construction of a similar ship, profiting by experience when it may have been sufficiently extended in the *Dauntless*, without impugning the general principles on which that ship was constructed; which, as well as most of the details, experience has shown to be correct.

The *Encounter* was ordered to be constructed to take the place, as to armament, of steam-sloops propelled with paddle-wheels, and of larger tonnage, generally between 1000 and 1100 tons burthen. The constructed tonnage of the *Encounter* was 896 tons. Her length between the perpendiculars was 180 feet, extreme breadth 33 feet 2 inches, and depth in hold 20 feet 10 inches. She was built with what was called a square tuck; but in that state she underwent no experiment for the determination of her speed. She was altered by an addition of 10 feet to the after body, whereby the form of the fore part of the aperture was brought to the same degree of fineness from the top to the bottom. Her tonnage was increased by the alteration from 896 to 953 tons.

The armament was at first intended to be six 10-inch guns, of 85 cwt. each; but that intention has not been carried into effect.

The *Niger* was constructed by Mr. Lang, for the same description of service as the *Encounter*. He constructed at the same time the *Basilisk* also, as it was understood, to give another fair trial to the two instruments of propulsion,—the *Niger* having a screw, and the *Basilisk*, paddle-wheels. The general similarity of the two ships was not strict enough to answer the object of a final experiment; a condition which may not, indeed, have been contemplated. But of what use are experiments, if they are conducted so loosely, that the inferences which it may be desirable to deduce from them, cannot be made with certainty? In the greatest speed of the vessels, at the load-draught of water, the *Niger* attained the greatest velocity in relation to the power exerted, by 1.45 per cent. At a draught of water diminished by about two feet, the paddle-wheels were more effective, whilst the power of the screw was unchanged, and in that state the speed of the *Basilisk* in relation to the power was 4.7 per cent. greater than that of the *Niger*, and at a mean draught of water it was 1.75 per cent. greater. In making such comparison it is important to notice, that the direct resistance of the *Niger*, or the area of the greatest transverse section, is greater than that of the *Basilisk* by 3¼ per cent.

There is one feature in the performances of the *Niger* that must be taken into account in relation to her speed, and that is the extraordinary amount of slip, in comparison of that of some other screw-vessels. It appears that in the best trials of the *Niger* the slip of the screw was 24 per cent. of the speed due to its revolutions. This may be accounted for in part, if not altogether, by the great relation of the pitch of the screw to its diameter, giving it an angle of 24° 16′ 30″.

The relative power of the propellers to overcome resistance was put to the same severe trial as it was in the *Rattler* and *Alecto*, and the result was similar: the two ships were fastened together by the stern, and both put in motion, when the *Niger* towed the *Basilisk* at the rate of nearly one and a half knot an hour. Both these experiments show that the screw is possessed of a decidedly greater power on the water than the paddle-wheel, and therefore it is a better propeller for steam-tugs. There is one other consideration that may be noticed in proof that the screw is the best for tug-vessels: the resistance opposed to the screw had much less power to diminish the speed of the piston and the power of the engines than the paddle-wheels,—a fact of considerable importance in this description of service.

The experiments have confirmed all preceding evidence, tending to show that the screw-propeller is a much more economical instrument than paddle-wheels, on the ground of its forming no impediment to the working of the ship under sail alone; seeing that a great portion of the service required of steam-ships and vessels of war can be performed under sail as well as by means of steam; and, therefore, the use of steam ought to be the exception in their service rather than the rule. This advantage is additional to those of the protection of the machinery, and the freedom of the decks and broadsides for the special purposes of ships of war.

The *Conflict* and *Desperate* have been constructed for the same description of service as the *Encounter*, and *Niger*.

There was a general unwillingness to hazard much by applying the screw-propeller to merchant vessels, before some satisfactory results should be obtained from the performances of the *Rattler*, as well regarding the power of the screw to propel the vessel, as to the best form of the screw. The Great Western Steam-ship company was a bold exception to that feeling of cautiousness and distrust; and the City of Dublin Steam-packet company also stood prominently forward in zeal for the introduction of the screw-propeller into commercial use. The *Margaret, Senator, Citizen,* and *Tribune,* were built for that company in 1843, and two others in 1844. The late earl of Auckland obtained, in the spring of 1848, a return of the screw-vessels used at the port of Liverpool, by which it appeared that in 1845 there were five screw-vessels; in 1846 there were about fifteen; and in 1847 there were about twenty-eight. It does not, however, appear that the screw-vessels of Dublin and of Liverpool were wisely managed; for whilst those places were identified with the most enterprizing zeal in bringing the screw-propeller into use, it was there associated with so much of failure and loss, that public confidence was greatly shaken; the failures being attributed, in general estimation, rather to the means of propulsion than to the true, but accidental cause. But Liverpool, which had gone far towards sacrificing the reputation of the screw, became in the latter part of the year 1848, the point of departure of the General Screw Steam-shipping company's auxiliary screw-vessels, trading between England and Constantinople; and the effect at Liverpool, of the success with which that trade has been carried on, has been a revival of public confidence in that propeller, to such extent that in less than a year the insurance on shipments in those vessels fell from four per cent. to one and a quarter per cent.

It appears from what has just been said, that from the time when the most satisfactory performances of the *Rattler* became known, the use of the screw increased at a great ratio in the commercial navy. On the other hand, the board of Admiralty looked for the most economical use of the screw in mercantile vessels, to infer therefrom the propriety of a similar application of it in the navy. The screw was applied very successfully by the General Screw Steam-shipping company, to vessels employed between London and two of the ports of Holland. The *City of London*, and *City of Rotterdam*, were similar ships, of 272 tons each, with a nominal power of 30 horses. They were formed suitably for the conveyance of cargoes, whilst the sharpness of the bow, and the fineness of the run, had reference to speed. When the vessels were under way, the screw was always used as an auxiliary propeller. In the year 1847 these two vessels made together eighty-six passages between London and Rotterdam, at the average speed of 7·92 miles an hour, consuming 75 pounds of fuel for each mile. During the same period the two similar ships, *Lord John Russell* and *Sir Robert Peel*, of 320 tons, and 40 horse-power each, performed together eighty-nine passages between London and Harlingen, at an average speed of 8·25 miles an hour, consuming 79 pounds of fuel for each mile. The small power employed in these vessels produces a speed of five miles an hour directly to windward, and enables them to make their passages with a regularity unhindered by such conditions of the weather as sometimes oblige large steam-vessels to return, unable to venture in the North Sea. Various ineffectual efforts had been made to render the screw-propeller subservient to the interests of commerce, and it is no disparagement of the screw that failure was repeated. It became, at length, the province of this company under the direction of Mr. Laming, to realise and carry out the plan of its successful working, both in short and long voyages. The same company had previously carried on a similar trade in fast sailing schooners, and the result of a comparison of the services of these two descriptions of vessels shows, that on an average the screw-vessels made four voyages to the sailing-vessels' one; and that, whilst the expenses of the sailing-vessels were at the rate of twenty-six shillings per ton for each voyage, the expenses of the screw-schooners were only sixteen shillings per ton for the like service. These vessels, therefore, exhibit important results in the certainty of passage, in the economy with which it is performed, and in the greater amount of service which any number of vessels so propelled can perform, than merely sailing-vessels. It may be observed, that the average speed of these four vessels, during one entire year, is the same that was estimated as attainable by powerful steamers when the project appeared of establishing steam communication between this country and the East Indies *via* Suez, whilst the steam power used to work the auxiliary propeller is considerably below one-half of the power applied to the large steamers used in the Indian Ocean. The results just stated were worthy of being taken as data in estimating the value of the screw as an auxiliary propeller in the light cruisers of the royal navy; and they appear to have been so regarded; for lord John Hay stated, in evidence before a committee of the House of Commons, that reference had been made to vessels "trading between London and Hamburgh and Harlingen," in determining the conditions for the sloops in which the Admiralty deemed it advisable to use auxiliary steam power and the screw.*

By a "tabular statement," published in the "Nautical Standard," of the dimensions, power, and expenses of mercantile steam-vessels, it appears that the original cost of paddle-wheel steamers, including all that is necessary to their fitness for sea, is, on an average, about 5*l.* 9*s.* per ton greater than that of screw-steamers, and that their current expenses for a year are about 8*l. per ton* more than those of screw-vessels; at the same time that the average "measure of cargo" is for screw-steamers 0·753 of a ton for each ton, builders' measure, whilst for paddle-wheel steamers it is only 0·425 of a ton. As "the dimensions of vessels, engines, sections, velocities, capacities, disbursements, and other statements, are based on practical results," † their general accuracy may be inferred; and, being so, the statement of facts requires no observation to add to its force.

The confidence which had been produced by the character and performances of the mercantile screw-schooners led to the fitting of the screw-propeller with auxiliary steam-power of sixty horses to the *Plumper* and *Reynard* sloops, leaving the further application of this power to that description of vessels to be made after experience should be gained. This has been partially obtained, and the capabilities of screw-vessels are now being more

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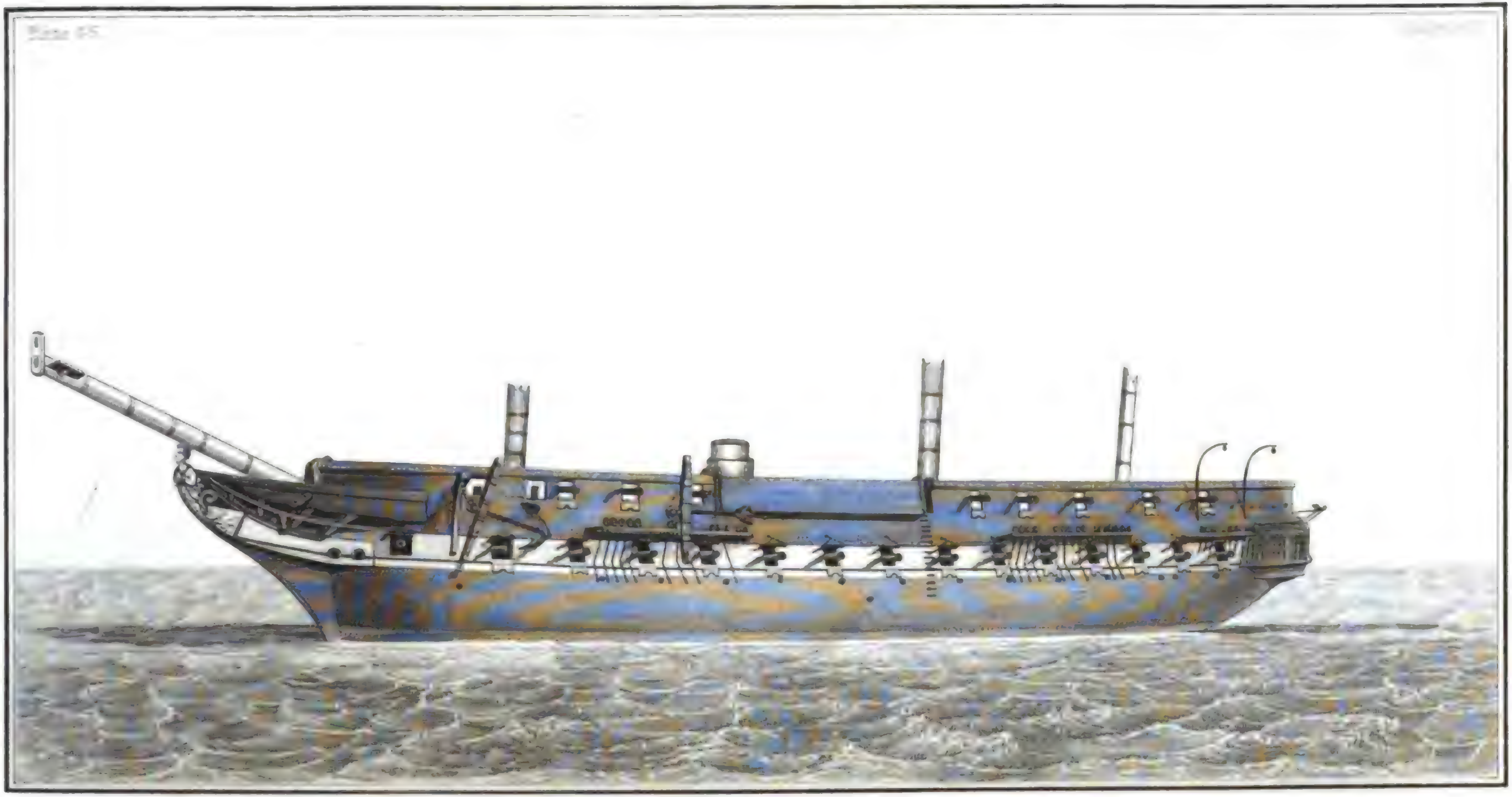
* Parliamentary paper, No. 555, session 1848.

† "Nautical Standard," vol. iv., p. 408.

THE ARROGANT FRIGATE,
with Screw Propeller and Auxiliary Steam Power.



fully developed in the service in which these two sloops are employed. The satisfactory character of these two vessels, which may be regarded chiefly as experimental,—the *Plumper* being stationed in the West Indies, and the *Reynard* in the East Indies,—will doubtless strengthen all the confidence which has been felt in the advantages of having an auxiliary screw with small power fitted to light cruisers. The following are the principal dimensions and power of the *Plumper* and *Reynard*:—

PARTICULARS.	*Plumper.*		*Reynard.*	
	ft.	ins.	ft.	ins.
Length between the perpendiculars . .	140	0	147	0
Length of keel for tonnage	124	10	128	4½
Extreme breadth	27	6	27	10
Breadth for tonnage	27	2	27	6
Moulded breadth	26	8	27	0
Depth in hold	15	9	14	6
Burthen in tons	489		516	

The armament of the *Plumper* is as follows: ten 32-pounders of 17 cwt. for the broadsides, and two 32-pounders of 56 cwt. for the extremities. That of the *Reynard* consists of ten 32-pounders of 17 cwt. for the broadsides, and one 32-pounder of 56 cwt. for the bow.

The plan of the late board of Admiralty, regarding the introduction of auxiliary steam-power into the navy, seems to have been taken with greater confidence. They did not wait for a precedent in private service; but, apprehending the coming wants of the navy, they deemed it necessary to provide for those wants in the best way they could; and, even whilst the experiments of the *Rattler* were going on, they began to order the construction of screw-frigates. The *Arrogant* (Plate 46) was the first frigate ordered to be built for auxiliary steam-power: she was constructed at the advice of the right honourable Sidney Herbert, when he was secretary of the admiralty. The decision was made to build that ship in 1844, a time when this country was opposed to the menacing attitude of France, whose rising steam navy excited the ambition of a naval prince of France for distinction to which that might be subservient. A scheme for the invasion of England was made public in a pamphlet, most unwisely sent forth; but the alarm it produced here was unquestionable. Aggression by means of a steam navy could be resisted on the sea, with a hope of success, only by a like power. Whilst the importance of having this power of defence was evident, the enormous expense at which a large navy of steam-ships could be maintained was not less evident. To moderate the expense, without foregoing the power, was the object of introducing a class of ships, in all respects perfect sailers, with relatively small power of steam. The result of the experiment has now been obtained, and has confirmed all the confidence in that arrangement which had been before supported by considerations derived from the application of steam-power under conditions somewhat dissimilar.

As an experiment, it has been entirely successful; but a question is suggested by a consideration of this success, whether a materially smaller relative power is not eligible for ships of that description. The path open to future experiment is that in which a greater diminution in the expense should be sought, as there is little doubt that the saving waits for the experiment. The *Arrogant* has one horse-power to 5·17 tons; and the more sparing apportionment of steam-power to tonnage in the two experimental sloops seems to justify the supposition that, as an auxiliary power in all classes of ships to which it may be applied, much less will be found enough.

During nearly thirty years the formation of a steam navy has been changing the character of England's defences; but a general view of the development of this power shows almost all that has been done to have been experimental, and however clearly the necessity of organization may have been seen, still, little has been done to realise it. Every person who has written intelligently on a steam navy has indicated the importance of classifying steam-vessels with reference to particular descriptions of service. The time has now arrived at which it seems to be incumbent on the government to form a system of classification, and to expand this power, to such extent as it may yet be wanted, under a wise distribution of the whole power into sections adapted to the various classes of service in which they will be required to engage. Such classification would have respect to the general dimensions of the ships, the proportion of steam-power to these dimensions, and the amount of armament.

For the defence of roadsteads and the principal harbours, large and heavily armed ships will be required, of the description now called steam guard-ships. The magnitude of the objects depending upon the protection of these, claims the greatest attainable efficiency in their adaptation.

The protection of the coast and of small harbours, will require a different class of vessels. These should be light and fast, with a moderate draught of water, the machinery well protected in its low position; and they should have full sailing power. With reference to this description of service, the *Rifleman* and *Sharpshooter* were designed by the author, at the request of Mr. Corry. It was further intended, in this experiment, to introduce into the navy a class of war steamers, more economical than any yet in the service, without being less effective. It was expected that these vessels would be built at about one-third of the expense of steam-vessels heretofore built for carrying the same armament which they were to carry; that is to say, one large gun at each extremity, and about four broadside guns. The current expense of working them would be reduced by the reduction in their crews, and by the diminished use of fuel,—in relation to the ship, not in relation to the armament. These vessels were intended to be employed upon the coast and in the channel, and were not at all intended for service on foreign stations; for that they were adapted in their general conditions; for this they were not remotely intended. They were *intended* to carry about six weeks' provisions and stores, and to receive only as many coals as the nature of the service required. With these conditions they were fully competent to carry the armament for which they were designed, in channel service. They are not perfect sailing vessels, inasmuch as the situation of the machinery and boilers excluded the main-mast from its right place. This is a defect in their qualifications for foreign service.

Steam-vessels for engaging in offensive operations,—as for assailing the enemy's coast,—should be able to carry heavy guns of long range, at the bow and stern, and a small broadside armament for defence. This class of vessels should be about 800 or 900 tons in burthen. They will require full sailing power, and the steam power to be auxiliary, having all the machinery protected from shot.

Steam-vessels for cruisers will not need large dimensions; about 400 or 500 tons burthen will perhaps be enough,—the principal armament being chase-guns of long range. As the service of these vessels would require great speed, the steam power must be relatively large: it must nevertheless be combined with complete sailing power. The expense of each of such vessels as these would be small compared with that of large paddle-wheel steamers, which have been accustomed, until recently, to carry only small armament; hence, as the cost of providing and maintaining each of these would be relatively small, so the number of them might be multiplied without greatly increasing the outlay.

Fleets of ships will need the help of steam power in general engagements. Other conditions being similar, that fleet which includes ships of the line with auxiliary steam power must be the more effective as the proportion of such ships is considerable. These could evidently take up any position at choice, changing places with certainty and rapidity. The want of such ships might be partially compensated by the presence of steamers of large power, for towing ships into the line and out of it, as such changes were needful; and also for effecting the best disposition of ships in the line.

Frigates or sloops, with auxiliary steam power, should be employed as convoys to fleets of merchants' ships.

For the conveyance of orders and despatches, vessels of about 400 tons burthen will be required, with full power of both sail and steam. These should carry only a few light guns, and be subjected to no unnecessary condition that would impede their velocity.

All these services require the sailing power to be complete, and the machinery to be below the water-line; and, therefore, the use of the screw-propeller rather than paddle-wheels. The experience which has been gained in the use and capabilities of the screw is now so ample, that the continued building of paddle-wheel steamers for any of these purposes may be regarded as a means of retarding the development of steam power in the navy, under conditions that would make it worthy of the confidence with which the country is looking to it, in the event of its being employed in war. It may be expected that the country will soon appreciate the superiority of the screw to paddle-wheels; and that, such judgment pervading the nation, the government will then relinquish the inferior system of propulsion, (which hardly differs materially from the wheels that were used with Mr. Miller's yacht, see p. 282,) and own the reasonableness of using the highest form of improvement in preference to all that has preceded, however decided the sanction of usage may have been. There is no reasonable doubt that a decision come to immediately, to have the screw-propeller fitted to all steamers that are yet to be built for any of the services just named, would be conducive to both economy and efficiency. Further experience is yet needed to determine the best proportion of steam power to tonnage in well-formed ships fitted with the screw; but it is certain that the proportion is considerably less than that required in propelling by paddle-wheels: and so the weight of machinery is diminished, whilst altogether it promotes stability. The saving applies to the original cost and to the current expense of working the engines.

The higher efficiency consists in having the machinery secured from danger; in having the sailing power of the vessels unimpaired; and in adding the power of steam to that of the wind, far more completely than it is possible to unite the same powers in using paddle-wheels.

As there is always a certain point in the radius of the paddle-wheel whose velocity is the same as that of the vessel, it is evident that if the floats were placed nearer to the centre than that point, the part of the float so placed would revolve with a less velocity than the vessel advances, and would therefore offer a resistance to her speed. This point approaches towards the circumference of the wheel, as the slip is diminished. The use of sail diminishes the slip; but before it can reduce it to nothing, a great part of the floats must oppose the speed of the vessel. Supposing the average slip of paddle-wheels to be about one-third, then the maximum of the ship's velocity would be attained before this one-third should be added. The paddle-wheels must, therefore, of themselves very soon fix a limit to the speed which would not be exceeded under the most favourable condition of the wind. If the wind is such as to produce any inclination, then both paddle-wheels work at a disadvantage in proportion to the extent of the inclination; and so a material part of the benefit of using the sail is lost by the less effective working of the paddle-wheels.

The importance of having screw ships complete as sailers, is strongly insisted on by naval men; and as the consideration of economy requires that sail rather than steam should be employed whenever the wind will supply the required power, it is desirable to ascertain to what extent the power of sail may be employed in screw steam-ships and vessels. This can, of course, be determined only by their stability; and as the stability of one ship can be compared with that of another, a comparison of ships of approved character, with screw-ships, may show whether the construction of steam-ships renders the application of full sailing power admissible. The following Table presents a comparison of several frigates whose calculated stability has been satisfactorily ascertained in actual service:

SHIP'S NAME.	$\frac{m}{M}$		$\frac{a}{D}$		$\frac{a}{A}$	
Raleigh . .	803	Relative inclining force, at an angle of 7 degrees.	9·5	No. of square feet of sail to every ton of displacement.	36.9	No. of square feet of sail to every square foot in the area of the midship section.
Leander . .	761		10·2		38·5	
Arethusa . .	726		9·9		36·7	
Indefatigable .	789		9·2		33·9	
Phaeton . .	1029		9·1		32·3	
Arrogant . .	950		8·3		36·3	
Dauntless . .	1100		7·5		32·9	
Thetis . . .	695		10·3		37·0	
Encounter . .	1314		8·2		31·4	

In the preceding Table, a represents the area of sail in square feet; A the area of the greatest transverse section in square feet; D the displacement in tons; M the moment of stability in tons; and m the moment of sail.

It will be observed that the quantity of sail is compared with two elements in the ship,—the displacement, and the area of the greatest transverse section; for, whilst the resistance of a body in passing through a fluid is materially affected by its form, as well as by the area of the greatest transverse section,—still, as in bodies not similarly formed, the displacement does not vary in a direct ratio with the greatest transverse section, it seems more likely to arrive at a just estimate of their sailing power from their quantity of sail, by making the weight which is to be moved through the water, as well as that element which seems most directly to affect the ship's speed, a subject of comparison.

Of the preceding examples, the *Arethusa, Indefatigable, Leander, Phaeton, Raleigh,* and *Thetis,* are sailing frigates; the *Arrogant* is a frigate with auxiliary steam-power and a screw-propeller; the *Dauntless* is a screw frigate, and the *Encounter* a screw corvette, both with full steam-power. Except the *Phaeton,* all the sailing frigates have more relative stability than the steamers; the *Arrogant,* with only auxiliary steam-power, has greater relative stability than either the *Dauntless* or the *Encounter*. It appears, therefore, that as steam machinery is applied to ships, the conditions of their construction must be such as to fix their stability at a less quantity relatively to their dimensions and tonnage. The Table shows also that the quantity of sail in relation to the displacement, is in every instance less in the steamers than in the sailing frigates. But as the steam-ships are relatively longer than sailing-ships, their area of greatest transverse section is relatively less than that of the sailing-ships; and in relation to this element, the *Arrogant* has more sail than either the *Indefatigable* or the *Phaeton,* and the *Dauntless* has slightly more than the *Phaeton.* The two forms of comparison together disallow the expectation that steam-ships may be as good sailers as sailing-ships of similar classes, unless the quantity of sail to be carried by them be determined by a different rule from that which has been commonly used in determining the quantity of sail for sailing-ships.

Before the screw-propeller was introduced into the navy, the capability of paddle-wheel steamers to carry sail had led to the fixing of a scale of masting for them considerably below that of masting for sailing-ships; and afterwards, when screw steam-ships were built, they were regarded as steamers to carry sail, rather than as sailing-ships to be furnished with steam-power; and so a low scale of masting was determined on for them also. But the conditions of ships propelled by the screw are so dissimilar from those of ships propelled by paddle-wheels, that neither as to stability nor to the circumstances in which sail should be used in screw-ships, should the quantity of their sail be inferred from the conditions of paddle-wheel steamers. A failure, as it seems, of recognising these differences, has placed screw-ships in a condition in which they cannot exhibit the full capabilities resulting from their construction, and from the low position of their machinery; for it is certain that their stability is sufficient to bear a higher scale of masting than that which has been officially sanctioned. And a just proportion of sail to that description of ships is necessary to the rank in which they are entitled to stand in relation to other ships of the navy.

The progress of experience with the screw has exhibited varying results, the elementary conditions of propulsion by that instrument not having been defined with sufficient accuracy to lead to uniformity in any number of subjects of experiment. Individually, there is much vagueness in the opinions of naval architects and of engineers as to the best conditions. Who has yet determined for a steamer the form which will overcome the resistance of the water with the greatest facility, and contribute most effectually to a good result of the screw? If the same conditions are not applicable to all degrees of speed, there is yet, without doubt, a definite relation between these two conditions for the development of the best result, at any given speed whatever. Now, although experience has failed of determining these and other conditions and relations of great importance, theoretical investigation has been recently pursued up to some most important definite results. The following note shows one of these results, and the application of the formula to several of the experiments in the table.*

Whilst all experience and effort at investigation have proved the subject to be very complicated and difficult of analysis, we may yet see that the power of the engine is absorbed by several resistances acting together, and which it is evidently not easy to estimate particularly. There are the resistance which the vessel has to overcome in moving the water from her path, and what is called the *minus* pressure; the friction of the water upon

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* It has been proved by theoretical investigation that

$$R'_{\varpi} = \frac{\pi \Upsilon_{\varpi}}{p I}, \quad . \quad . \quad . \quad . \quad . \quad . \quad (a)$$

when the vessel and the rotation of the screw have attained a uniform motion; where

R'_{ϖ} = the accelerating force necessary to resist the motion of the vessel, moving with a velocity v, and with ϖ pounds pressure of steam in the cylinder.

Υ_{ϖ} = the number of units of moment of force when ϖ pounds pressure, as measured by the indicator, are applied to the piston.

π = 3.1416, &c.

p = the pitch of the screw.

I = the moment of inertia of the screw.

A unit of moment is one pound avoirdupois, acting at a distance of one foot from the centre of the axis of the screw.

If we assume the relation

$$R'_{\varpi} = m A'' v^2,$$

which is not far from the truth, where A'' is equal to the area of the greatest transverse section of the ship, and m is a constant quantity, we shall have

$$v^2 = \frac{\pi \Upsilon_{\varpi}}{m A'' p I} \quad . \quad . \quad . \quad . \quad . \quad . \quad (b)$$

Hence this important result—the square of the velocity of the vessel, is directly proportional to the moment of the engine, and reciprocally proportional to the rectangle of the pitch of the screw and its moment of inertia.

With the same vessel, and with the same moment of the engine, but with a different screw, we shall have

$$v_1^2 = \frac{\pi \Upsilon_{\varpi}}{m A'' p' I'};$$

$$\text{Whence } \frac{v^2}{v_1^2} = \frac{p' I'}{p I}, \quad . \quad . \quad . \quad . \quad (c)$$

$$\text{Or } v^2 \times p I = v_1^2 \times p' I'.$$

If $p I$ be less than $p' I'$, then v will be greater than v_1; and when $p I$ is a minimum, the velocity of the vessel will be a maximum.

the entire surface immersed in the water, and the resistance occasioned by the rising of the water at the bow and its depression at the stern of the vessel. The question requiring to be solved is, how to reduce to a minimum these several obstacles to a vessel's passage through the water: in order to this, it is necessary that the elevation and depression of the water, at the bow and stern respectively, should be as small as possible; and that the form of the body should be such as to impress the least possible motion on the least possible quantity of water, in passing through it. All this applies to a vessel whatever be her means of propulsion. But there is a further absorption of power in steam-vessels. The propeller acts in a yielding medium; and as the fluid yields to the pressure of the screw, a quantity of water is thereby displaced, at the expense of a further amount

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With the same vessel, and with a different power and screw, we shall have

$$v_1^2 = \frac{\pi \Upsilon_{\varpi'}}{m A'' p' I'};$$

$$\text{Whence } \frac{v^2}{v_1^2} = \frac{p' I' \Upsilon_{\varpi}}{p I \Upsilon_{\varpi'}} \quad . \; . \; . \; . \; . \; (d)$$

Now, if $I = I'$, we shall have

$$\frac{v^2}{v_1^2} = \frac{p'}{p} \frac{\Upsilon_{\varpi}}{\Upsilon_{\varpi'}}.$$

The following applications of the formula show how nearly experiment agrees with the result which it enunciates. It will be seen, on referring to the Table, that the velocity is noted in feet per minute; the force of the engines is proportioned to the moments; and the moment of inertia is assumed to be the same for the two screws used in the same ship, the diameters being nearly or quite equal.

The first illustration is obtained from the two trials of speed with the *Ajax*,—the pitch of the screw having been altered. Then

$$\frac{v^2}{v_1^2} = \left(\frac{659}{720}\right)^2 \propto \frac{17 \times 854}{19{\cdot}5 \times 820};$$

$$\text{Or } \left(\frac{659}{720}\right)^2 = {\cdot}84 \propto \frac{17 \times 854}{19{\cdot}5 \times 820} = {\cdot}908.$$

The next illustration is taken from the *Termagant's* trials; here

$$\frac{v^2}{v_1^2} = \left(\frac{851}{964}\right)^2 \propto \frac{(17 \text{ ,, } 2\tfrac{1}{2}) \times 1124}{18 \times 1333};$$

$$\text{Or } \left(\frac{934}{969}\right)^2 = {\cdot}93 \propto \frac{(17 \text{ ,, } 2\tfrac{1}{2}) \times 1124}{18 \times 1333} = {\cdot}80.$$

The last illustration is obtained from the experiments with the *Plumper*; here

$$\frac{v^2}{v_1^2} = \left(\frac{753}{734}\right)^2 \propto \frac{(4 \text{ ,, } 6\tfrac{1}{2}) \times 148}{(5 \text{ ,, } 7\ ) \times 139}$$

$$\text{Or } \left(\frac{753}{734}\right)^2 = 1{\cdot}05 \propto \frac{(4 \text{ ,, } 6\tfrac{1}{2}) \times 148}{(5 \text{ ,, } 7\ ) \times 139} = {\cdot}86.$$

of power; and the friction of the water upon the surface of the propeller absorbs another portion of the power. These two are also required to be reduced to a minimum; and inquiries and experiments in steam navigation, by means of the screw, have aimed at this object. Science has not determined the conditions which would give the minimum absorption of power by the working of the screw; and whilst experience has realised a considerable measure of success, it has failed of arriving at any thing nearer than a somewhat uncertain approximation.

Experiment ought, therefore, to be directed to a determination of the conditions individually. Each condition should be defined, experience having shown the attainable limit of excellence. A combination of such would then produce what is sought in vain in the endless variety of steamers, having scarcely two conditions exactly alike in any two: for even if excellence is attained, it is excellence without a defined relation of cause and effect, generally. But until the relations which particular causes bear to effects, are known, the building of steamers must remain, to no inconsiderable extent, a matter of doubtful experiment.

Under the circumstances which have hitherto prevailed in the use of the screw-propeller, great difficulties have existed in making experiments. With the same nominal power of engines, screws of dissimilar conditions have been used; the vessels, bearing similar engines and screws, have been commonly dissimilar; often it has happened that they have met the direct resistance with considerable inequality, or the after part, affecting the working of the screw, may be differently formed in the two or more vessels. If all other conditions are alike, and yet the pitch of the screws is different, in relation to their diameters, the actual result will be different; the pitch of the screw and the speed of the engine may not be the best suited to each other; and the best result cannot in that case be obtained. It has been observed in some experiments, that whilst a greater power has been exerted, and also a greater speed of the screw, a corresponding increase in the speed of the vessel has not been obtained. But the same nominal, or even the same actual power in the cylinder, by no means implies the same *moment* of power employed to turn the screw round, which is really the element on which comparisons should be based, in aiming to determine the relative efficiency of different engines constructed for driving the screw-propeller.

The object to be sought in screw propulsion is, to have a pressure upon the posterior side of the screw at any required speed of the vessel, equal to the resistance which the vessel has to overcome at that speed. The speed of the vessel will not exceed the limit at which the opposite forces are in equilibrium; the desiderata are, therefore, the conditions of equilibrium at any speed that is required for the vessel. It is an invariable fact, that if the form of the after body, near the run, presents a difficulty to the influx of the water at the part in which the screw works, the pressure on the screw is abated, and the result is an increase of slip, in a proportion, which has not yet been defined, to the magnitude of that difficulty. And, on the contrary, if the form of the after body is such as to determine the free influx of the water upon the posterior face of the screw, in the condition in which it is called a following current, the screw may *appear* to have no slip, and even to propel the vessel at a greater speed than if it were working in a solid nut. This fact was observed whilst the *Archimedes* was under experiment; and was at that time referred to this cause. But it has since been the habit to reason on the screw with the idea of its working in *still* water. With that idea, the alleged fact was unaccountable; and the readiest way to dispose of the question was, to reject altogether, on the assumption of inaccuracy, the statements of such experiments as were said to have shown a velocity in the ship greater than was accounted for by the number of revolutions which the screw had made. This is not, however, the only condition which magnifies the slip; if the pitch of the screw is too great, the lateral resistance is too great also, and the direct resistance being then too small, there is of necessity too great a slip. When excessive slip results from such a cause, a diminution of the pitch of the screw is the proper remedy.

Experience has therefore shown, that there is a condition in the use of the screw in which the vessel passes over a distance greater than the number of the revolutions multiplied into the pitch of the screw would show. The fact has been confirmed in both the *Arrogant* and the *Plumper*. The experiment of the *Arrogant* shows that when she was going 8.26 knots per hour, the speed of the ship was greater by 1.2 per cent. than was due to the number of revolutions of the screw. It will be observed also, that the pitch of her screw was less than that of either of the other screws of the same diameter, its angle being 17° 7′ 20″. Again, with the *Plumper*; when the pitch of the screw was 5 feet 7 inches, and its angle 11° 29′, and the power exerted by the engines that of 148 horses, the actual speed of the ship was 7·387 knots an hour, being greater by 17·28 per cent. than would have resulted from the same number of revolutions of the screw in a solid nut. And when the pitch of the screw was only 4 feet 6½ inches, its angle being 9° 23′, the power of the engines exerted, that of 139 horses, and the revolutions of the screw increased from 115 to 136¼ per minute, the speed of the ship was 7·2 knots per hour, the excess in the speed of the ship being at the rate of 18·77 per cent. The speed of the ship was, however, less by about one-fifth of a knot per hour with the smaller pitch, than with the greater pitch. It appears from these facts, that the screw with the larger pitch was the better one; for, with a smaller number of revolutions of the screw by 21·25 in a minute, the speed of the ship was greater.

It will be observed, that the angle of the *Reynard's* screw is very nearly a mean between the angle of the *Arrogant's* screw and that of the *Plumper's* best screw. And further, the difference in the speed of the *Plumper* and

Reynard, in relation to the speed of their screws respectively, was 26·14 per cent. It is clear that the screw was of such an angle that it was capable of taking advantage of the following current. But, unlike the two others, it had a slip. And this fact indicates that the form of the ship is not adapted to the relative pitch of the screw, in order to its producing the best effect. The *Reynard* has a finer run than the *Plumper*; whence it appears that a want of fineness is not the fault. It appears also, that there is a limit to the fineness of the run, which cannot be exceeded without disadvantage; if it is so, then it is worth some care to ascertain, for future guidance, what that limit is, under given conditions of required speed.

There are two other ships on the list, which have been tried with different screws, and which exhibit results that are not unimportant. The *Ajax* was tried with a screw of 19 feet 6 inches pitch, whose angle was 21° 12′ 20″; the power exerted was that of 854 horses, producing 41·5 revolutions in a minute, and a velocity in the ship of 6·46 knots an hour, with a slip of 18·5 per cent. The other screw, whose pitch was 17 feet 11 inches, and angle 19° 37′ 30″, was of the same diameter. The power exerted was, in this case, less by thirty-four horses, the revolutions were increased to forty-eight, and the speed of the ship to 7·06 knots per hour, the slip being reduced to 16·18 per cent. The *Termagant* does not supply so unequivocal an experiment, because the power of the engines was increased to a considerable extent when the angle of the screw was diminished. The effective power of the engines being that of 1124 horses, the revolutions of the screw sixty-six in a minute, its angle 20° 17′ 15″, the speed of the ship was 9.16 knots per hour, with a slip of 21.38 per cent.; and when the power was increased to that of 1333 horses, the revolutions to seventy-three in a minute, and the angle of the screw reduced to 19° 27′ 20″, the speed of the ship was increased to 9·51 knots an hour, with a slip of 22.78 per cent. Thus, it appears that the power was increased by eighteen per cent., the number of revolutions by ten per cent., and the speed by five per cent.; and that whilst the angle of the screw was diminished by about four per cent., the slip increased by six per cent.,—an anomalous result, which can be accounted for only on the supposition of an error in either making or noting the observations. The elements in these experiments varied too much to admit of certain inferences.

The following Table contains all the experiments that I have been able to collect, with the conditions noted in sufficient detail for any thing like a satisfactory inference. And it might be wished, that the power stated to have been employed had been rather the moment exerted in turning the screw round, than the power of the steam in the cylinder. Some results which, in this case, might be arrived at by comparison, would be rather approximations to the truth than certain necessary consequences that must follow from the actual conditions of the ships and of their machinery.

SHIPS' NAMES.	Screw.									Effective power of Engines.	Space moved over in one revolution of the screw.		Speed in feet per minute.		Slip per cent.	Ship.		Relation of the effective power of the engines to the	
	Diameter.		Pitch.		Area.	Angle.			Revolutions per minute.		Ship.	Screw.	Ship.	Screw.		Area of the greatest transverse section.	Displacement in tons.	Area of the greatest transverse section, in square feet.	Displacement in tons.
	ft.	ins.	ft.	ins.	sq. feet.	°	′	″		h. p.	feet.	feet.				square feet.			
Ajax . .	16	0	19	6	88·6	21	12	20	41·5	854	15·90	19.50	659	809	18·54	702	2819	·822	3·300
	16	0	17	11	93·7	19	37	30	48	820	15·00	17·91	720	859	16·18	761	3089	·928	3·767
Blenheim .	16	0	20	0	101·6	21	42	0	43	825	13·60	20·00	585	860	31·97	693	2763	·840	3·349
Arrogant .	15	6	15	0	110·8	17	7	20	55·5	682	15·10	15·00	842	832	Excess 1·20	570	2450	·835	3·592
Termagant	15	6	18	0	84·0	20	17	15	66	1124	14·15	18·00	934	1188	21·38	518	2034	·461	1·809
	15	6	17	2½	84·1	19	27	20	73	1333	13·38	17·21	969	1255	22·78	591	2408	·443	1·806
Dauntless	14	8	18	0	77·1	21	22	15	56·138	805	13·50	18·00	751	1010·5	25·69	522	2242	·648	2·785
	14	8	18	0	77·1	21	22	15	68·276	1225	15·32	18·00	1046·6	1229	14·84	522	2251	·426	1·837
Encounter .	12	0	15	7	53·4	22	19	5	77·5	642	13·48	15·58	1045	1207	13·42	320	1194	·498	1·859
Plumper .	8	9	5	7	25·4	11	29	0	115	148	6·50	5·58	753	642	Excess 17·28	205	540	1·385	3·648
	8	9¼	4	6½	25·3	9	23	0	136·25	139	5·40	4·54	734	618	18·77	210	555	1·510	3·992
Reynard . .	8	11	7	3	29·6	14	31	0	112	153	6·60	7·25	740	812	8·86	220	584	1·437	3·817

So far, actual experience in steam navigation enabled us to go. It indicated the probability of advantage in the use of screws of smaller pitch than those which have been generally used; but it left much to be determined before a general law could be deduced for the construction of the screw, with reference to the effect it should produce. Neither the royal navy nor the mercantile service proffered the information from which a law might be deduced; it was then necessary to seek this at another source.

Several series of experiments have therefore been made on a model, under the author's direction, to determine the relative effects of screws, varying in their angles from 8° 27′ to 21° 57′ 37″. There were thirteen screws, constructed on a scale in a definite relation to a screw of fifteen feet in diameter. These screws were used to propel a model of a ship made upon the same scale in relation to a ship. The experiments were made in a long trough. The moving power in the model was a strong and accurate spring, the moment of whose power is expressed in the Tables. The first screw was the model of one whose pitch was seven feet; and the increase in the pitch of each screw, following consecutively in the series, represented one foot on the full scale. In each of the series of experiments, from the first to the third, all the elements were constant except the pitch and the length of the screw; the alteration in the angle of the screws, resulting simply from the alteration in the pitch, is not an additional but a concomitant variation. It is shown in the Tables of experiments, that, except in the sixth, seventh, and eighth series, the area of the blades of the screws was kept constant; for this purpose the screws were of different lengths. The variations in the conditions under which the experiments were made, were thus reduced to the smallest possible number,—in the first instance to two, and subsequently to one. The number of revolutions made by the screw in each experiment was 216; each experiment was repeated several times, and the mean of these was recorded. Looking at the first series of experiments, it is seen that the speed of the vessel increased from the first up to the third, and then it decreased progressively through the remainder of the series. It is shown also, that the slip is smallest with the smallness of the angle; but from the first screw to the third, the increase is relatively smaller than the increase of its speed; hence it became more effective up to the limit of an angle of 10° 57′. From this limit to the end of the series, the effective power of the screw diminished progressively. Hence it appears that a screw, whose pitch is in such a relation to the diameter, that the angle of its blade is about 11°, is the most effective in its operation, subject to all the conditions which were included in the experiments. The second and third series of experiments show similar results, when the draught of water was successively increased; and thus tend to the establishment of the inference to which the first series led.

FIRST SERIES.

Screw : 3·75 inches in diameter, and 4·41 inches area of the blades.			Power exerted in pounds avoirdupois.	Space moved over in one revolution of Screw.		Speed in feet per minute.		Slip per cent.	Vessel.	
Pitch.	Angle.	Revolutions per minute.		Vessel.	Screw.	Vessel.	Screw.		Area of the greatest transverse section.	Weight in pounds avoirdupois.
Ins.	° ′ ″			foot.	foot.				sq. inches.	
1·75	8 27 0	317	21*	·119	·145	37·72	46·23	18·41	26·3	23·78125
1·90	9 25 0	306	”	·127	·158	38·86	48·45	19·79	”	”
2·30	10 57 0	260	”	·153	·192	39·78	49·83	20·17	”	”
2·39	11 45 0	255	”	·150	·199	38·25	50·78	24·67	”	”
2·81	13 15 0	222	”	·170	·234	37·74	51·98	27·53	”	”
3·00	14 17 15	214	”	·176	·250	37·66	53·50	29·60	”	”
3·25	15 25 25	195	”	·184	·270	35·88	52·81	32·05	”	”
3·50	16 32 50	183	”	·196	·291	35·86	53·37	32·81	”	”
3·75	17 39 29	172	”	·203	·312	34·91	53·75	35·05	”	”
4·00	18 45 20	162	”	·205	·333	33·21	54·00	38·50	”	”
4·25	19 50 18	155	”	·207	·354	32·08	54·90	41·56	”	”
4·50	20 54 25	150	”	·213	·375	31·95	56·25	43·20	”	”
4·75	21 57 37	143	”	·220	·397	31·46	56·60	44·41	”	”
SECOND SERIES.										
1·75	8 27 0	310	21	·101	·145	31·31	45·20	30·74	33·5	28·71875
1·90	9 25 0	300	”	·109	·158	32·72	47·97	31·11	”	”
2·30	10 57 0	255	”	·132	·192	33·66	48·87	31·16	”	”
2·39	11 45 0	250	”	·128	·199	32·00	49·79	35·73	”	”
2·81	13 15 0	212	”	·148	·234	31·37	49·64	36·80	”	”
3·00	14 17 15	204	”	·149	·250	30·39	51·00	40·41	”	”
3·25	15 25 25	190	”	·156	·270	29·64	51·45	42·39	”	”
3·50	16 32 50	168	”	·157	·291	26·37	49·00	46·18	”	”
3·75	17 39 29	156	”	·160	·312	24 96	48·75	48·80	”	”
4·00	18 45 20	146	”	·166	·333	24·23	48·66	50·20	”	”
4·25	19 50 18	140	”	·169	·354	23·66	49·58	52·27	”	”
4·50	20 54 25	136	”	·171	·375	23·25	51·00	54·41	”	”
4·75	21 57 37	130	”	·176	·397	22·88	51·41	55·49	”	”
THIRD SERIES.										
1·75	8 27 0	288	21	·094	·145	27·07	42·00	35·54	36·1	34·09375
1·90	9 25 0	277	”	·102	·158	28·25	43 86	35·59	”	”
2·30	10 57 0	234	”	·122	·192	28·54	44·85	36·36	”	”
2·39	11 45 0	228	”	·120	·199	27·36	45·41	39·74	”	”
2·81	13 15 0	201	”	·136	·234	27·33	47·07	41·93	”	”
3·00	14 17 15	191	”	·138	·250	26·35	47·75	47·82	”	”
3·25	15 25 25	180	”	·146	·270	26·28	48·75	46 09	”	”
3·50	16 32 50	165	”	·151	·291	24·91	48·12	48·23	”	”
3·75	17 39 29	151	”	·158	·312	23·85	47·18	49·44	”	”
4·00	18 45 20	143	”	·160	·333	22·88	47·66	51·99	”	”
4·25	19 50 18	137	”	·163	·354	22·33	48·52	53·97	”	”
4·50	20 54 25	130	”	·166	·375	21·58	48·75	55·73	”	”
4·75	21 57 37	124	”	·174	·397	21·57	49·08	56·05	”	”

The fourth and fifth series of experiments included only two screws, which were tried under different conditions of the motive power, and of the draught of water. The results of the alterations will be seen by comparing those two series with the first and third series of experiments: the same screw still produced the best effects.

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* This gave a moment of ·00117; the unit of a moment being one pound avoirdupois acting at a distance of one foot.

FOURTH SERIES.

Screw: 3·75 inches in diameter, and 4·41 inches area of the blades.			Power exerted in pounds avoirdupois.	Space moved over in one revolution of Screw.		Speed in feet per minute.		Slip per cent.	Vessel.	
Pitch.	Angle.	Revolutions per minute.		Vessel.	Screw.	Vessel.	Screw.		Area of the greatest transverse section.	Weight in pounds avoirdupois.
Ins.	° ′ ″			foot.	foot.				sq. inches.	
2·30	10 57 0	216	18	·148	·192	31·96	41·40	22·80	26·3	23·78125
3·50	16 32 50	144	„	·200	·291	28·80	42·00	31·42	„	„
2·30	10 57 0	212	„	·114	·192	24·16	40·64	40·52	36·1	34·09375
3·50	16 32 50	141	„	·142	·291	20·02	41·12	51·31	„	„
				FIFTH SERIES.						
2·30	10 57 0	208	15	·146	·192	30·36	39·87	23·85	26·3	23·78125
3·50	16 32 50	133	„	·196	·290	26·00	38·79	32·97	„	„
2·30	10 57 0	202	„	·112	·192	22·62	38·71	41·56	36·1	34·09375
3·50	16 32 50	129	„	·137	·291	17·67	37·62	54·47	„	„

Hitherto the screws have differed in length, that the area of the blades might be a uniform element throughout the series. But the length of a screw in relation to its pitch had been found of considerable importance in the experiments made with the *Rattler*. In the screw which produced the best effect in the *Rattler*, as to both the speed of the vessel and the smallness of the slip, the length was only ·1136 of the pitch; whilst the length of the screw, which was found in the experimental series to produce the best effect, was ·164 of its pitch. But it is clear that the *Rattler's* screw had too great a pitch in relation to its diameter to produce the best effect; its diameter was only ·909 of its pitch, giving an angle of 19° 18′ 15″; whilst the diameter of the best screw in the experimental series was 1·629 of the pitch, giving an angle of 10° 57′. Since the principal elements of the *Rattler's* screw were not justly proportioned to each other, it cannot be inferred from the conditions which it presented that the relation of its pitch to its length is the best for a screw of the right construction. But, as it was important to establish this relation, seven screws were brought to a uniform length, and three further series of experiments were made with them, under conditions corresponding with those of the first, second, and third series. The results of these new experiments are shown in the sixth, seventh, and eighth series; and it will be seen, by reference to the Table, that the screw whose angle was 10° 57′, was made the basis of the series, the length of the others having been reduced to conform to it. In a comparison of the corresponding experiments in the first, second, and third series, and in the sixth, seventh, and eighth series, it will be seen that, with the diminished surface of the blades, the speed of the screws increased in every experiment; the slip increased also. A further comparison of the second and third series with the seventh and eighth, shows also that, in some of the experiments in which the pitch of the screws was relatively large, the result of diminishing their length was a greater absolute velocity in the vessel, notwithstanding the increase of slip. But the great relation of the slip of the screw to the speed of the vessel, is such as to show that the power expended in producing the result, is much greater than that which produces an equal result with screws of smaller angle; any further extension of the inquiry in this direction would be rather wandering from the required point of truth than an approximation to it.

SIXTH SERIES.

Screw: 3·75 inches in diameter, and ·387 inches in length.						Power exerted in pounds avoirdupois.	Space moved over in one revolution.		Speed in feet per minute.		Slip per cent.	Vessel.	
Pitch.	Angle.			Area.	Revolutions ℘ minute.		Vessel.	Screw.	Vessel.	Screw.		Area of the greatest transverse section.	Weight in pounds avoirdupois.
Ins.	°	′	″				foot.	foot.				sq. inches.	
2·30	10	57	0	4·41	260	21	.153	·192	39·78	49·83	20·17	26·3	23·78125
2·39	11	45	0	4·01	270	"	·132	·199	35·64	53·77	33·72	"	"
2·81	13	15	0	3·63	250	"	·141	·234	35·25	58·54	39·78	"	"
3·25	15	25	25	3·30	235	"	·143	·270	33·60	63·64	47·20	"	"
3·75	17	39	29	3·05	217	"	·151	·312	32·76	67·81	51·68	"	"
4·25	19	50	18	2·86	185	"	·168	354	31·08	65·50	52·54	"	"
4·75	21	57	37	2·69	160	"	·173	·397	27·68	63·30	56·27	"	"
SEVENTH SERIES.													
2·30	10	57	0	4·41	255	21	·132	·192	33·66	48·87	31·14	33·5	28·71875
2·39	11	45	0	4·01	266	"	·115	·199	30·59	52·98	42·26	"	"
2·81	13	15	0	3·63	245	"	·118	·234	28·91	57·37	49·60	"	"
3·25	15	25	25	3·30	229	"	·120	·270	27·48	62·02	55·69	"	"
3·75	17	39	29	3·05	209	"	·127	·312	26·54	65·31	59·36	"	"
4·25	19	50	18	2·86	180	"	·138	·354	24·84	63·75	61·03	"	"
4·75	21	57	37	2·69	156	"	·147	·397	22 93	61·75	62·85	"	"
EIGHTH SERIES.													
2·30	10	57	0	4·41	234	21	·122	·192	28·54	44·85	36·36	36·1	34·09375
2·39	11	45	0	4·01	255	"	·103	·199	26·26	50·87	48·28	"	"
2·81	13	15	0	3·63	239	"	·108	·234	25·81	55·96	53·87	"	"
3·25	15	25	25	3·30	220	"	·111	·270	24·42	59·58	59·01	"	"
3·75	17	39	29	3·05	206	"	·117	·312	24·10	64·37	62·56	"	"
4·25	19	50	18	2·86	180	"	·128	·354	23·04	63·75	63·85	"	"
4·75	21	57	37	2·69	152	"	·132	·397	20·06	60·16	66·65	"	"

The ninth series of experiments was made to determine the effects of powers acting directly to pull the vessel through the water. They are sufficiently defined and reported in the Table to obviate the need of further explanation.

The tenth series included the two powers whose effects had been already determined separately. The object of making them was to ascertain whether a screw, whose form is the most effective alone, is also the most effective in combination with another means of propulsion,—a condition found in experience whenever the screw is employed as an auxiliary propeller.

NINTH SERIES.

Moving power acting directly by means of a cord passing over a pulley.	Space moved over in one minute.	Vessel.	
		Area of the greatest transverse section.	Weight in pounds avoirdupois.
	feet.	Square inches.	
1 lb. avoirdupois.	36·84	26·3	23·78125
2 "	55·50	"	"
4 "	82·80	"	"
1 "	33·54	36·1	34·09375
2 "	43·03	"	"
4 "	67·20	"	"

TENTH SERIES.

Screw : 3·75 inches in diameter, and 4·41 inches, area of the blades.					Power exerted.	Space moved over in one revolution of Screw.		Speed in feet per minute.		Surplus of the vessel's speed, or slip, per cent.	Vessel.	
Pitch.	Angle.			Revolutions ᵽ minute.		Vessel.	Screw.	Vessel.	Screw.		Area of the greatest transverse section.	Weight in pounds avoirdupois.
Ins.	°	′	″			foot.	foot.				sq. inches.	
2·30	10	57	0	308	1 lb. and Engine.	·194	·192	59·75	59·03	sur. 1·22	26·3	23·78125
3·00	14	17	15	254		·205	·250	52·02	63·50	slip 18·07	"	"
3·75	17	39	29	202		·254	·312	51·32	63·12	" 18·69	"	"
4·75	21	57	37	162		·294	·397	47·62	64·12	" 25·73	"	"
2·30	10	57	0	290		·146	·192	42·34	55·58	" 23·82	36·1	34·09375
3·00	14	17	15	236		·178	·250	42·00	59·00	" 28·81	"	"
3·75	17	39	29	180		·231	·312	41·58	56·25	" 26·08	"	"
4·75	21	57	37	152		·247	·397	37·54	60·16	" 37·60	"	"
2·30	10	57	0	324	2 lbs. and Engine.	·214	·192	69·33	62·10	sur. 11·64	26·3	23·78125
3·00	14	17	15	281		·250	·250	70·25	70·25	00·00	"	"
3·57	17	39	29	241		·314	·312	75·67	75·31	sur. 00·47	"	"
4·75	21	57	37	210		·400	·397	84·00	83·12	" 1·05	"	"
2·30	10	57	0	296		·177	·192	52·39	56·73	slip 7·65	36·1	34·09375
3·00	14	17	15	254		·235	·250	59·69	84·66	" 29·49	"	"
3·75	17	39	29	220		·274	·312	60·28	68·75	" 12·32	"	"
4·75	21	57	37	185		·342	·397	63·27	73·23	" 13·60	"	"
2·30	10	57	0	381	4 lbs. and Engine.	·237	·192	90·30	73·02	sur. 23·66	26·3	23·78125
3·00	14	17	15	360		·291	·250	104·76	90·00	" 16·40	"	"
3·75	17	39	29	309		·347	·312	107·22	96·56	" 11·04	"	"
4·75	21	57	37	223		·416	·397	108·67	103·31	" 5·19	"	"
2·30	10	57	0	360		·215	·192	77·40	69·00	" 12·17	36·1	34·09375
3·00	14	17	15	284		·252	·250	71·56	71·00	" 00·79	"	"
3·75	17	39	29	240		·300	·312	72·00	77·08	slip 6·59	"	"
4·75	21	57	37	209		·393	·397	82·13	82·80	" 0·81	"	"

It appears, from these experiments, that when the power employed supplementary to the screw was relatively small, the screw which had been the most effective alone, was still the best, at each draught of water; but when that supplementary power was increased, the same screw no longer produced the best effect. The screw of 21° 57′ 37″ was the best with each of these greater supplementary powers, and at each draught of water. It appears from the several results exhibited by these experiments, and by those in the first and third series, that when a screw of the right construction is used in connection with another power, such as sail, the additional speed obtained by means of the other power, ought to be at least equal to the slip to which the screw would have been subject if it had been working alone.

Upon a cursory inspection of some of these experiments, it appears that the pressure of the water was on the anterior face of the blades of the screw, since the speed of the vessel was in excess of that due to the revolutions of the screw; and that therefore the screw must have retarded rather than increased the speed of the vessel. In one experiment the speed of the vessel was precisely the same as that due to the revolutions of the screw; and hence, if it had been working in still water, there would have been no pressure on either side of the blades, and no effect could have been produced by it upon the speed of the vessel: the screw would have been working on the surface of vanishing pressure.* But whilst the screws were working in those two conditions, the vessel had a velocity considerably greater than that which was due to the weight that was acting conjointly with the screw. The screw was, therefore, increasing the speed of the vessel. Hence, the pressure must have been on the posterior face of the blades; and that pressure must have been produced by the flowing in of the water at the stern of the vessel to fill up the void space which the motion of the vessel was making.

Experience, gained in actual service, agrees with that which has been here detailed. The *Encounter*, in the experimental squadron, was subjected to a trial in which the power of the screw, added to that of the wind on the sails, increased the speed of the ship by about forty per cent. The ship, under sail, was going at 9·5 knots, and the steam being then got up, the speed of the engines produced seventy-seven revolutions of the screw in a minute, and increased the speed of the ship to 13·237 knots an hour: hence, the speed of the ship was greater than that due to the number of revolutions of the screw by 12·45 per cent. It will be observed, on referring to the table (p. 376), that the angle of the *Encounter's* screw is more than 22°, being, as it appears by other experiments, better suited to service of that description than to be used without sail.

The several series of experiments in which the most general comparison of screws was made, show that the least relative pitch gives the least relative slip. But as the number of revolutions of the screw must be increased to compensate for the smallness of the pitch, the friction of both the machinery and the screw is increased by diminishing the pitch, or the angle of

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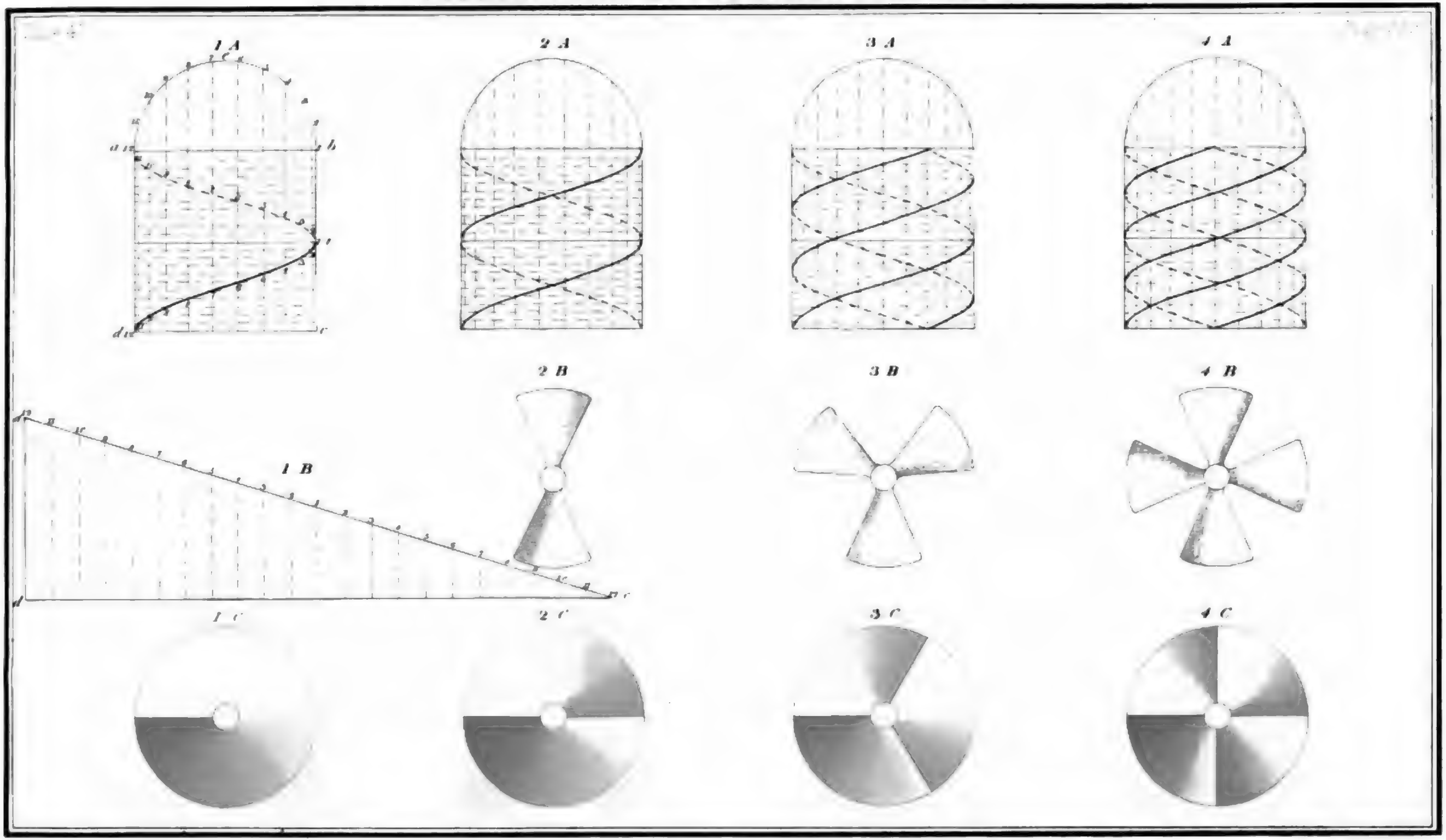
* See Rawson's "Screw Propeller," for an exposition of the surface of vanishing pressure.

CONSTRUCTION OF THE SCREW PROPELLER.



the blades. It is important, therefore, to determine the condition, in actual service, in which the angle of the screw, whilst not admitting of the least amount of slip, shall yet produce the best result. Such a condition is indicated in these experiments,—the more certainly, as, at the several draughts of water, the same screw, acting alone, always produced the best effect.

The Tables of experiments show that the pitch of the first six screws does not increase by a uniform quantity. This irregularity was owing to a want of exactness in casting four of them. Until after the experiments had been made, the inaccuracy of the screws was not detected; but, in examining and comparing the results of several series of experiments, irregularities of similar character were traced in the performances, for which the data did not account. The screws were then carefully measured, and the results of the experiments were revised upon the basis of the exact dimensions of the screws. The results then showed a consecutive increase of slip from the screw of the smallest pitch to that of the largest, and a general regularity in the variations of speed; that is, an order very near to an exact gradation in the increase of the speed of the vessel from the first screw to the third, and then a diminution from that limit to the end of the series. An exact uniformity does not prevail; and it is probable that minute discrepancies which may be found would have been avoided, if the times could have been noted at less intervals than seconds. The results are, however, sufficiently exact to indicate a general law under which variation takes place.

Plate 47 represents the construction of the screw-propeller. Fig. 1 *A* is the projection of a cylinder on a plane, of which *a b* is the diameter, *a d* the height, and *a e b* half the circumference. The diameter and the height of the cylinder are here the same. The vertical lines are determined at equal distances apart on the circumference, *a e b;* and the transverse lines, corresponding to semi-circles upon the cylinder, are at equal distances apart, and are double the number of vertical lines, or they agree with the entire number that would be drawn upon a cylinder. The curve, *a i d,* is a line of sines, being the projection of a helix upon a plane. Fig. 1 *B* is the development upon a plane of the part of the cylinder out of which the screw is cut, *a d* being the height of the helix or the pitch of the screw, *c d* its circumference, *a c* the line corresponding to the helical line, *a c d* the angle of the screw,—and the vertical lines corresponding to the vertical lines on fig. 1 *A*. Fig. 1 *C* is an end view of a screw-propeller, consisting of one complete turn of the blade upon the axis.

Fig. 2 *A* is the same as fig. 1 *A*, except that, having two helices described, it is intended for a double-threaded screw. Fig. 2 *B* is the projection of this screw, each blade consisting of a small section of the entire blade; fig. 2 *C* is an end view of a two-threaded screw, each blade consisting of half a turn on its axis.

Fig. 3 *A* is the delineation projected for a three-threaded screw; fig. 3 *B* is a projection of a screw with three blades; and fig. 3 *C* is a projection of the same form of screw, the blades making together a complete turn on the axis.

Fig. 4 *A* is the delineation projected for a screw with four blades: fig. 4 *B* is a projection of a four-threaded screw; and fig. 4 *C* represents the same form of screw, making altogether a complete turn on the axis.

The steam navy of France began to be formed, like that of England, apparently with very different objects from those with which it has been more recently in the course of development. Of the nine steam-vessels which were included in the French Navy on the 1st January, 1829, it does not appear that any remain at the present time. None of their present steam-vessels was launched before the year 1830; *l'Ardent*, of 160-horse power, is the oldest, having been launched in May 1830. She underwent a thorough repair in 1841. From 1830 till 1837, most of the French steamers were built for engines of 160-horse power,—of some the power was not so great; they were of the class called *avisos*, or despatch vessels. Together with vessels of the same class and power, others of the same class, but of larger dimensions and greater power, were built in 1838 and the two following years. Amongst other steam-vessels launched in France in 1841, were two steam-frigates, constructed by M. Hubert, of 450-horse power, of large capacity, having a displacement of 2696 tons. In 1842 the number of steamers launched was a little increased, much more so was it in 1843—including frigates, corvettes, and despatch vessels. The general plan of their steam navy may be regarded as having been then formed, as it included a considerable number of ships which had been built and armed expressly for the operations of war, as well as vessels of lighter construction for services requiring greater speed: for although some ships of larger dimensions have been more recently added to the French steam navy, these are rather exceptions than otherwise. It might be expected that, from this stage of development, many things would be suggested in the course of experience, for extending and perfecting that power. The same emulation which prevailed in the councils of France, determining the formation of a navy of sailing ships, in the latter part of the seventeenth century, has prevailed in the nineteenth: hence, the construction of a steam navy. And it may be affirmed that emulation has all along been the one ruling principle in states, regarding the formation of naval power. The list of French steam ships and vessels, inserted at the end, will show more fully, and in detail, the progress which has been made in providing for the carrying on of naval warfare. It will be seen also that the greatest efforts of France and of England were made about the same time, to multiply the number and magnify the power of their respective steam-ships. Each nation was so especially the object of the other in this respect, that any effort made to increase the steam navy of one state, appeared to the eyes of the other an act of rivalry, and led to corresponding effort: thus, progress in the formation of the steam navies of England and France has been very similar. In England, the usage of the service has been to obtain all marine engines from private engineers, under contracts. The same plan, it appears, was tried in France, but without giving satisfaction; hence, there are now steam factories, for the construction, as well as repair, of engines, at the principal naval arsenals of that country.

On Iron Ship-building.

The suitableness of iron as a material for ship-building, and the rapid increase, recently, of its application to this purpose, merit some notice. The history of iron vessels lies within the limit of one's memory; and the gradual development of their capabilities and advantages may be traced back only to a very few years.

Iron boats were first built for the navigation of canals; and the origin of them belongs, by general consent, to about the beginning of this century. A considerable period elapsed before any more important use was made of them; for, though iron vessels were used as steamers, before they were used with sail-power, it was not till 1821 that a steam-engine was employed as the motive power to an iron vessel. The first iron vessel in which steam-machinery was employed was the *Aaron Manby*, constructed by a company formed at Horsley, by Messrs. Manby and Napier, now rear-admiral sir Charles Napier. The parts of this vessel were sent to London, where they were put together. She was then sent to France, under the command of captain Napier. Another iron steam-vessel was constructed some time afterwards by Mr. Manby, intended for the navigation of the *Seine;* but in consequence of a prohibitory law in France regarding foreign vessels, the parts were sent to France, and put together at Charenton. Mr. Manby built two others there, for the navigation of the same river. The building of iron vessels was now soon commenced by an engineer at Paris, for the navigation of the Seine.

The Shannon steam-packet company was the next to employ iron steam-vessels in river navigation. The first of these was built by the Horsley company, in 1824; and this beginning was followed by the building of five more for the same company, as they were required.

The use of the small number of iron vessels already built for companies both in Great Britain and on the Continent, was determining the problem of the suitableness of iron to ship-building, and was drawing attention to the subject. Messrs. Fawcet and Preston established a factory at Liverpool for building them; and their first iron vessel was built under the direction of Mr. Page. This was the first iron vessel built at that place. Mr. Laird, of Birkenhead, came next; and, proceeding upon a large scale, prosecuted this branch of art with uninterrupted success. Mr. Fairbairn early took a part in its cultivation; and ranks with those to whose influence and skill it is indebted for public confidence. After having begun at Glasgow, he came and established himself upon the Isle of Dogs, where he became one of the principal constructors of iron vessels upon the Thames. And whilst his skill has been followed by success, there have been other eminent engineers pursuing the same branch of art with the like results: amongst these are Messrs. Miller and Ravenhill, whose vessels are of exquisite workmanship and beauty of form; and Messrs. Ditchburn and Mare, who have built a considerable number of iron vessels, amongst which is the *Fairy*, tender to the Queen's yacht, whose form and speed have gained her a high reputation.

Experience soon proved the advantages of iron vessels for the navigation of rivers. But what was untried was far from being obvious; and strong prejudices, unreasonable doubts, and real difficulties had to be overcome, as to their suitableness for navigating the ocean. One of the chief objections to this more extended use of iron vessels was the perturbations of the compass.* Iron packets began, however, to be used on the coasts; and the art of building them advanced gradually towards perfection. They therefore acquired a merited confidence; and iron sailing-vessels were built for foreign service. Amongst these was the *Iron sides*, built at Liverpool in 1838, and which made several successful voyages to America.

But before this time, Mr. Laird had constructed several iron steam-vessels, to be employed in America and in the East Indies. They were, however, sent out in pieces, with workmen to put the parts together. And he has continued, with equal success, to construct and send out iron ships to different parts of the world.

Mr. Laird was followed by other constructors of iron vessels at Liverpool; the high estimation in which they were held having led to a constantly increasing demand for them, not only in number, but also in the capacity of the vessels. Messrs. Tod and McGregor, of Glasgow, took a leading position in building iron vessels;—these were superior both in size and speed. Their iron sailing-vessels were from 200 to 300 tons burthen, and their steamers from about 120 to more than 200 feet in length; the *Princess Royal*, being one of the largest, became also one of the fastest iron steam-packets of her time (see p. 323). Mr. Wingate and others followed in the same line, upon the Clyde. It has been stated that the vessels built on the Clyde were generally lighter than those built by Mr. Laird, but unequal to them in the finish of their work. And the different mercantile ports soon vied with each other in the excellence of the iron ships and vessels which they produced; although, perhaps, none have yet equalled the skill in the arrangements of Mr. Laird's yard, and the excellence of the ships which are built there.

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* Professor Airy has since published a very concise series of instructions for correcting the compass on board of iron ships.

But the most magnificent specimen of iron ship-building that has yet been produced, was the *Great Britain*, constructed by Mr. Patterson, at Bristol, for the Great Western steam-packet company. The following were the principal dimensions and weights of this extraordinary ship.

	feet.	ins.
Length from the extremity of the knee of the head to the after part of the taffrail - - - - - - -	317	3
Length from the perpendicular forward to the after part of the second sternpost - - - - - -	292	0
Length to the after part of the first sternpost - - -	278	0
Main breadth, over the ribs at the height of twenty-four feet, under the floor-timbers - - - - - -	51	0
Breadth, at the water-line, at the height of sixteen feet -	46	0
Depth, under the floor-timbers amidships - - -	32	3

Weight of the hull, not including fittings	iron - -	840 tons.
	wood - -	160 „
	Total - - -	1000 tons.

This ship was calculated to have a total displacement of 3900 tons, which would bring her draught of water to nineteen feet two inches, and give her an area of midship-section, below the water-line, of 730 square feet. This allowed for every equipment and supply, including 1000 tons of fuel, 500 tons of merchandise, and 300 persons, and passengers' luggage.

The engines of this ship were of 1200 horse-power, and worked with four cylinders, inclined at an angle of 45° towards the diametrical plane of the vessel, and were placed, two on the starboard, and two on the port side, acting directly upon two cranks at the end of a shaft parallel to the length of the ship, by means of rods articulated upon the piston rods. There were two iron-plate condensers, each serving for the two cylinders which acted upon the same crank. In each of these condensers worked an air-pump, to which the movement was always communicated by the same crank-pin, and by a rod articulated upon the rod of the pump. One of these air-pumps was deflected a little from the vertical position, to allow the shaft of the propeller to pass, which, in the midst of four cylinders, carried a drum, receiving the movement from another still larger, placed above it upon the principal shaft.

Principal Dimensions of the Machinery.

Diameter of the steam-cylinders - - - -	88 inches.
Length of the stroke - - - - - - -	6 feet.
Number of strokes of the piston in a minute - - -	20.
Diameter of the large drum - - - - -	24 feet.
Diameter of the small drum - - - - -	6 feet.
Number of revolutions of the screw - - - -	80.
Number of blades of the screw - - - - -	4.

	ft.	ins.
Length of each blade projected on a plane parallel to the axis -	4	6
Height from the centre of the shaft of the screw to the beginning of the floor-timbers - - - - - -	7	9
Height of the centre of the shaft of the large drum - -	25	3

The advantages of iron vessels consist, generally, in their durability, strength and safety, capacity for stowage, economy and salubrity. Prior to experience, it was apprehended that the saline property of the sea-water would have a strong corrosive effect on the iron; and that this material would be rapidly destroyed. But experience has shown that the effect of salt-water on *iron alone* is so small as hardly to bear a comparison with that which it has upon iron in connection with wood. And this remarkable difference of effect has been shown in iron vessels in which timber was used for the keel: for the bolts which had been driven through the keel to form its proper connections, have been acted upon with a rapidity almost to destroy them, before the iron plates forming the external parts of the hull had become perceptibly diminished in thickness by the same agency;—an important condition being, that the vessel should be kept in use, rather than lie up unemployed. Vessels which were built in the earliest stage of this art, subsequent to that of building mere canal-boats, bore the service many years, needing but little repair; and remained in a perfectly good condition to a later period than that to which the durability of wooden vessels ordinarily, and under similar circumstances, extends.* Since the inner surface of the iron plates may be almost wholly protected from oxidation, the external wear is nearly all that is to be apprehended. The outer surface of the metal might also be protected in a great measure from corrosion; but yet the vessels were subject to the great disadvantage of having their speed diminished, after a very short period of service, by the adhesion and growth of animal and vegetable matter. The coating of red lead which, until recently, was supposed to be the best means of protecting the iron, included no element inimical to animal and vegetable life, under the circumstances in which it was used. The formidable character of this species of mischief threatened to fix a disadvantageous limit to the employment of iron ships and vessels both for commercial and naval purposes, and as well in other countries as in England. But Mr. Hay, the chemical lecturer at Portsmouth dockyard, has succeeded in producing a composition to protect the iron from the chemical action of the sea-water, and also to prevent the adhesion of marine vegetables and animalculæ. This protection is formed on a purely scientific basis. A coating is applied, which serves simply to protect the iron, being a non-conductor of electricity. Upon this is applied a coating with oxide of copper, which prevents the adhesion of animal and vegetable substances. The application of this protective varnish to the insides of iron ships would be of great value in preventing the oxidation of the iron.

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* There is a great difference in iron plates: some are inferior, and soon oxidate, as *best*; others are very superior, and last a long time, as *best best*, &c.

It is doubtful whether iron ships have yet been long enough in use to show how long they may remain fit for service. But the facts already known are highly satisfactory, as evidence of great durability, under just conditions.

And it is a consideration which should not be overlooked, that large ships may be rendered much more durable than small vessels. For, as the weight of the hull is generally determined in a certain proportion to the whole displacement, and the plates of iron are much thicker in a large than in a small ship, whilst the oxidation produces only a uniform waste of metal, the durability will be great, in proportion to that quantity of the thickness by which the plates may be reduced without endangering the ship.

The superior strength of iron ships depends on two facts; the character of the material, and the mode of combining it. The strength of wrought iron is well known, as its power of bearing strains in almost every direction has been often proved. Its resistance to *lateral* pressure is increased in a much higher ratio than the quantity. And from this fact, it follows, that almost any amount of strength may be given to a large fabric: certainly enough to bear the pressures and strains to which ships are exposed, with much less liability to injury than wood has been known to bear them. With plates of iron of a substance fitly proportioned to the magnitude of the fabric, and with joints properly formed, the sides of ships have been found capable of resisting, in a remarkable manner, forces for which the strength of timber would be insufficient. A substance of plates, sufficient to constitute this amount of strength generally, is also able to bear concussions of great force, with much less hazard than timber would. This has been proved by a number of instances of iron ships and vessels being placed in the most dangerous situations. These facts have been made public by means of reports presented to the House of Commons, and through other mediums; and have been corroborated in the course of extending experience. At the same time, this superiority is obtained with a less weight of material than that which is given to ships with a scantling of timber sufficient for ordinary strength.

The preceding remarks indicate the fact of greater safety; because the security must be in such proportion as a ship is capable of enduring, unhurt, the casualties of tempests, rocks, and shores. The greater degree of safety of iron ships has been proved in those cases which have ascertained the superiority of strength; and it is shown by the manner in which concussion produces effects. Experience has shown that unless the concussion takes place with great violence, mere indentation of the metal is generally the greatest injury sustained. Beyond this, the concussion and the strain sometimes break off the heads of a few rivets without opening the seam; but it is uncommon for the rivets to be drawn, if the metal and workmanship are good. When, in addition to the concussion being exceedingly powerful, the object against which it takes place is sharp, as a crag of rock or coral, it occasionally happens that a hole is made through the plate. But when such an accident occurs, the damage is generally, if not always, *local,*—the parts not immediately subject to the concussion remaining unhurt by the shake. No general leakage is therefore consequent upon such an accident.

As the hull of an iron ship is both thinner and lighter than that of a wooden ship, an iron ship of the same external dimensions as a wooden one has both the greater capacity for stowage, and the greater power to support the weights that may be put into her. The differences vary in some degree with the dimensions and form of the ship, being greater as the dimensions of the ship are large. They may, of course, be determined by computation; and an iron ship will carry considerably more cargo than a wooden ship of the same external dimensions.

The consideration of economy should not be omitted in any comparison of the merits of ships built of timber and of iron. The economy begins at the building; for the original cost of an iron ship is considerably less than that of a wooden one; and it runs on with the course of the ship's service, as a result of several causes; amongst them, of the smaller amount, and less expensive character of repairs. And as it is not yet known how long iron ships will last, the saving which will result from using iron instead of wood cannot be estimated. The period of service of mercantile timber-built ships is defined. If they reach, or rather exceed, thirty years' service, they must have been ships of the first class as to quality; and must, within that time, have undergone expensive repairs. As iron ships are not subject to the same decay, at the same time that accidental damages are generally repaired at a much less cost than they are in wooden ships, all that is gained by the diminished expense of repairs is clear *profit*. The excess in absolute durability, be it what it may, is to be added to this. And the greater space for stowage, as compared with wooden ships, is a further saving gained by the use of iron ships.

The adaptation of iron as a material for ships to be used in war has been affirmed on the ground of experience, supplied by the *Nemesis*, war-steamer, in the service of the East India company, in the war in China. So far as the experience of that ship, and of her companions in that service, built of wood, extended, the grounds of preference appear to have been decidedly on the side of iron. The testimony regarding the *Nemesis* rests on the authority of captain William Hutchens Hall, R.N., who commanded that ship during the period of her employment in that service. Apart from experience, much doubt has prevailed whether danger from shot-holes would not be far greater in iron ships than in wooden ships. This is a question which ought, no doubt, to be answered with certainty, before the dangerous services of naval warfare are entrusted to iron ships.

The *Dover* was the first iron steam-vessel built for the government service; she was ordered in February and March 1839, and was used as a packet on the Dover station. This was followed by the building of three others, the *Alert, Soudan,* and *Wilberforce,* for the Niger expedition; they were all small vessels, designed expressly for the exploration of that river. The order to built these was given in August 1840. In June 1841, the admiralty ordered the *Mohawk,* of sixty horse-power, to be built for service on lake Huron; and in September of the same year, the *Rocket* and *Ruby* were ordered to be built for steam-tenders. None of these, therefore, were either intended or suited for the purposes of war. It was not until the year 1843, that the building of iron steam-vessels for war was begun. The *Trident,* of 850 tons, and 350 horse-power, was the first, and was built by Messrs. Ditchburn and Mare, at Blackwall. The next iron steamer that was ordered to be built was the *Birkenhead,* of 1400 tons, and 556 horse-power, built by Mr. Laird. Having paddle-wheels, her armament consists of only six guns, although her rate is that of a frigate. Before any others were ordered to be built, the *Princess Alice* and the *Dwarf* were purchased; but neither of them was intended for war. In January and February 1844, the *Bloodhound, Jackall, Lizard, Myrmidon,* and *Torch,* of 150 horse-power, and the *Harpy,* of 200 horse-power, were ordered to be built, varying from 340 to 378 tons. In July of the same year, the *Grappler* was ordered to be built, of 559 tons, and 220 horse-power; and to carry three guns. The whole of those which had been ordered to be built, until this time, were intended to be propelled with paddle-wheels,—a condition which interfered with the freedom of armament. The *Dwarf,* which had been built for a screw, and had in the mean time been bought, was intended chiefly for experiment. In November 1844, the *Fairy* was ordered to be built for a tender to the royal yacht, to be propelled with a screw. The next iron steamer ordered to be built was the (*Pegasus,* since named) *Greenock,* frigate, of ten guns,—of 1412 tons, and 540 horse-power, to be propelled with a screw. In March 1845, the *Megæra,* of 1395 tons, 350 horse-power, and ten guns; the *Simoom,* a ship of beautiful form, of 1979 tons, constructed for engines of 780 horse-power, but ultimately fitted with other engines of only 350 horse-power, and of eighteen guns; and the *Vulcan,* of 1747 tons, 350 horse-power, and fourteen guns, were ordered to be built, and to be propelled with a screw. In the course of the same year, the *Sharpshooter, Minx, Oberon,* and *Triton,* gun-vessels, were ordered; and the *Onyx, Violet,* and *Antelope,* packets. And in 1846, three of the new packets, required for the Holyhead and Dublin station, were ordered to be built of iron.

England having set the example in building war-steamers of iron, the French followed it, in the development of their steam naval power. In

March 1840, the *Ténare*, an *aviso*, or despatch vessel, of 160 horse-power, and 765·58 tons displacement, was launched. The *Australie*, and the *Narval*, of the same power, followed in 1844; and the *Chaptal*, of 220 horse-power, in 1845. In 1846, the *Anacréon*, of 100, the *Eclaireur*, of 180, and the *Passe-Partout*, of 120-horse-power, were launched. And since 1844, considerably the larger number of war-steamers, laid down by the French, have been iron vessels: the largest of these was the *Caffarelli*, 209 feet in length between the perpendiculars, 35·1 feet in breadth moulded, and 15·25 feet in depth from the load-water line to the upper part of the keel; with a displacement of 1862 tons. In 1845, one first-class and two second-class steam corvettes were laid down; in 1846, two second-class corvettes, seven first-class and two second-class *avisos* were laid down; and in 1847, the only iron ships laid down for the French navy, were two first-class and two second-class *avisos*. By the "*Budget des dépenses de l'exercise*, 1849," it appears that there was not a single iron steamer laid down in 1848. Thus, it seems, that confidence in the suitableness of iron for such purpose, rose and fell in the governments of England and France about the same time, and in about the same degree.

The merits of iron ships for war, in relation to wooden ships, had in the mean time been extensively considered; but as few persons could be informed by experience regarding the fitness of iron ships to serve in war, much objection has been urged against them, having only conjecture to rest upon. Experiments have been made at the arsenal at Woolwich, to determine the effect of shot upon iron plates, rivetted together like the sides of an iron ship, and lined with a material called kamptulicon. The chief ingredients in this material are india-rubber and prepared cork; and it was thought that, by lining the sides of a ship, between wind and water, with a considerable thickness of this material, it would close up after the entrance of a shot, and exclude the water. This supposition was found to be true in the first trials; but when the shot struck on the side of the kamptulicon, as it would do in passing out of a ship, on the side opposite to that at which it had entered, it forced this material along with it, thereby making the hole in the iron still larger; but as the kamptulicon, which was forced outwards, was not torn away, it collapsed, as it had done at the other side. But the experiments failed of supplying evidence enough to decide the question at issue. Another experiment was made at Portsmouth, to try the effect of shot upon the sides of an iron vessel; this was the *Ruby*, which has been already mentioned. One of the engineer officers who surveyed her before the experiment, stated in evidence before a Committee of the House of Commons, that the iron of which she was constructed was originally very thin, not thicker than a half-crown; that she was in a very bad state of repair; that the heads of the rivets were quite gone, especially internally; that many of the seams of rivets were almost gone; that the ribs were very wide apart; and that a part of the deck of the vessel had been taken out for the purpose of removing the machinery, thereby increasing her weakness.* The shot, of course, tore the plates of iron apart, along the lines of rivets, without any difficulty; but no experiment could fail more completely than this did, of deciding the question for which it was ostensibly undertaken.

Experiments of a more definite character have been made to determine the absolute effects of shot upon plates of iron, a few of which may be mentioned. Musket-shots were fired against plates $\frac{3}{16}$, $\frac{1}{4}$, and $\frac{3}{8}$ of an inch in thickness, at a distance of forty yards. In the first instance, the shot passed through, making a ragged hole; in the second, a bur was raised, and opened at the crown, but the shot did not pass; and in the third, a bur was raised to the height of $\frac{1}{4}$ of an inch.

Grape-shot also were fired at an iron plate of the same thickness. At the distance of 100 yards a round hole was made with a considerable bur; and at a distance of 200 yards a ragged hole was made, about which the iron was much torn. Grape-shot were fired also at plate-iron half an inch thick; at the distance of 100 yards, a bur was raised to the height of half an inch, but the shot did not pass. At the distance of 200 yards, the iron was indented to the depth of a quarter of an inch. Iron plate, $\frac{5}{8}$ of an inch thick, was fired at with the same description of shot; at the distance of 100 yards the plate was indented $\frac{5}{16}$ of an inch; and at 200 yards it was indented $\frac{3}{16}$ of an inch. At a distance of 100 yards, iron plate $\frac{3}{4}$ of an inch thick was fired at, and indented $\frac{1}{4}$ of an inch; and at 200 yards, it was indented $\frac{1}{8}$ of an inch.

Further experiments have been made recently, to determine the effects which would be produced by heavy shot and shell, on plates of iron of the substance of those which have been used in the sides of a steam-frigate—five-eighths of an inch thick. In the first course of these experiments, a butt was used which represented the iron-work of a part of the side of the *Simoom*, without the lining of wood which that ship has. The effect of shot was such as could hardly fail of being disastrous in a naval engagement. The shots were broken into pieces by the concussion, and passed through the butt in fragments. Portions of the iron immediately struck by the shot were broken into fragments, and a hole formed in the plate a little larger than the shot. The fragments of the shot and of the iron plate then diverged, taking a considerable range in their flight.

In the next course of experiments, a similar iron butt was filled in between the angle irons with timber $5\frac{1}{2}$ inches thick, placed vertically; and this was covered with plank from $2\frac{1}{2}$ to 4 inches thick, placed longitudinally. In these experiments the internal effects of shot were about the same as in the experiments previously made: the shot having been broken into fragments by the concussion, the parts passed through the iron plate and the timber, forcing through the hole, parts of the iron plate in fragments, the whole of which, on clearing the wood, flew about in all directions. In the next course of experiments, the iron butt was covered on the outside with fir plank: still the effects of the concussion were similar;—the shot were broken into fragments, and the iron plate was broken off by the passage of the shot, with a rim less ragged than it was when the wood was used as a lining; and the fragments were thrown about as before.

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* Parliamentary Paper, No. 555, Session 1848.

The use of kamptulicon has since been tried as a lining to a similar iron butt;—the first experiment was inconclusive, and subsequent trials have been unfavourable. Notwithstanding the unsuccessful nature of the experiments, it appeared that there was ground to expect kamptulicon might yet produce a more beneficial result than anything else has yet been found capable of doing.

An inference has been drawn from the results of the various experiments, unfavourable to the employment of iron ships in warlike operations. The effect of that inference has been, to alter the entire plan of the government, as to the use of iron ships in the navy.

There is one view of this subject that should not be overlooked,—as it may be of the highest consequence,—that is, the *abundant* supply of the material in our own country. The immediate supply makes the building of iron vessels more expeditious than that of wood; whilst the repairs, being much less, are less expensive, and more quickly performed. These advantages are already available for commercial purposes; and considering their magnitude, it does seem an important question—to what extent, and for what purposes, would it be for the benefit of the English nation to employ iron ships and vessels in the royal navy? The question seems now to rest on the internal effect of shot. If, therefore, any means can be used of sufficient power to diminish this effect in iron ships to as small an amount as it is in wooden ships, it would be of almost primary importance to the navy, since iron ships might then be rendered fit for any of its uses.

The Royal Yacht Squadron.

Amongst the various lines of practice in private yards, in which naval architecture has improved of late years, the building of yachts is perhaps the chief. "THE ROYAL YACHT SQUADRON" was the first combination for this object;—it was then, however, known as the "THE YACHT CLUB." This was formed in the year 1815, at a meeting of noblemen and gentlemen held in London for that purpose. "THE YACHT CLUB" included forty-two original members, who, having formed themselves into a body, resolved that the future condition of membership should be "the ownership of a vessel not under ten tons." No record has been kept of the number of yachts and their tonnage, belonging to the members at that time; but it is supposed they did not exceed ten or twelve, with a total amount of tonnage from 150 to 200.

The members of the yacht club carried their own influence, and increased their importance corporately, as they went on. In 1817 the Prince-regent signified his wish to be a member; and in 1818 the duke of Clarence and the duke of Gloucester also joined the club. In July of that year, the terms of membership were raised; and it was declared that "the necessary qualification for a candidate hereafter, be the *bonâ fide* ownership of a yacht not under *twenty* tons." In the course of five years, the size and number of the yachts increased considerably; and on the 5th of September, 1820, it was notified that his Majesty, George IV., desired that the club might be thenceforth styled "THE ROYAL YACHT CLUB."

In September, 1826, it was determined that in future the qualification of a gentleman to become a member should be the possession of a yacht not under *thirty* tons; and this regulation still remains.

In July, 1827, the late earl of Yarborough, one of the original and most zealous members of the club, was chosen commodore; and being in that high relative position, he used his personal influence, his wealth, and his hospitality, to promote the interests and respectability of the club, and to unite the members together in prosecuting the one object for which they were thus associated. Harmony and zeal were thereby promoted: and he continued to exert the same beneficial influence for a period of about twenty years, retaining the post of commodore until his death.

The progress of the club was such, that, in 1828, it contained one hundred and seventeen members, and three hundred and thirty-four honorary members; (it having been declared, in 1818, that all officers of the navy, not under the rank of commander, were eligible to be elected honorary members;) the number of yachts was ninety-six, amounting to 6721 tons.

His Majesty, William IV., became the patron of the club, in July 1830; and in July 1833, he directed "that as a mark of his Majesty's gracious approval of an institution of such national utility, it is his gracious will and pleasure, that it shall henceforth be known and styled 'THE ROYAL YACHT SQUADRON,' of which his Majesty is graciously pleased to consider himself the head."

The object of the members of this distinguished institution having been, from the beginning, to obtain the highest degree of excellence of which vessels of the classes they possessed were susceptible, and a great measure of success having attended their efforts, it appeared to the author, between twenty and thirty years ago, that one effectual way to extend the improvements which had been made in the construction of vessels of the yacht class, would be to publish the dimensions and calculated elements of some of the most distinguished vessels belonging, at that time, to the club. He obtained permission from several noblemen and gentlemen, who were members, to "take off" their yachts. The elements of construction, and other information, of six yachts, were therefore published in the first volume of "PAPERS ON NAVAL ARCHITECTURE."* The first intention was to get a large fund of such information, as that the yachts might be compared with reference to their sailing and other qualities, and to the elements of their construction; and by that means, principles be deduced for the extension of improvement. But he was hindered from carrying out his purpose so far as would have supplied a sufficient body of facts for induction, upon which improvements in the construction of that class of vessels might be carried on with certainty.

Soon after the accession of Her Majesty Queen Victoria, she became the patroness; and she has continued the annual plate of one hundred guineas to the regatta of the royal yacht squadron. Eminent success has attended the enterprising zeal of the members, and the talent which has been exercised under their patronage. The character of the yachts which compose this squadron is too well known to need more than an allusion to it here;—all that wealth and talent, in the present state of naval architecture in this country, have been able to obtain, has been obtained in the yachts belonging to the "Royal Yacht Squadron,"—which, a year or two ago, amounted in number to one hundred and two; with an aggregate of 9600 tons burthen, employing one thousand two hundred seamen. At the same time it included, under the patronage of the Queen,—Prince Albert, and one hundred and sixty other members—noblemen, gentlemen, and naval and military officers. It enrolled, also, five hundred and five honorary members. The number of vessels belonging to the squadron has since that time diminished by ten; but as there have been added other vessels of greater tonnage, the diminution in this respect is less than 200 tons. The present state of the squadron (August 1850) is as follows: one brig, of 120 tons; forty-three schooners, of 5894 tons; thirty-nine cutters, of 2780 tons; seven yawls, of 543 tons; and two luggers, of 75 tons: making a total of ninety-two vessels, of the collective burthen of 9412 tons, old measurement.

The yachts of this squadron are found cruising in every part of the world; and they are admitted into all, or nearly all, ports, free of port charges. The annual regatta is in the month of August, at Cowes.

As the vessels alluded to, whose elements were published in "PAPERS ON NAVAL ARCHITECTURE," possessed respectively a high character, and as that work had not a great circulation, and is now out of print, it may be useful to insert those elements here, and also to add to that number those of several yachts of more recent date, which the author has constructed for the persons whose names stand in connection with them. The *Falcon, Coquette, Pearl, Nautilus,* and *Emerald,* are the yachts whose elements were published before; these were constructed with fuller lines, according to the usage of the time in which they were built, than the other yachts, which are of more recent date. Of these, the *Lotus* is but just built.

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* P. 212 et seq.

ELEMENTS OF VESSELS OF THE ROYAL YACHT SQUADRON.

ELEMENTS.	NAME OF YACHT, AND FOR WHOM BUILT.											
	Falcon—The Right Hon. the Earl of Yarborough.	*Erminia*—The Rt. Hon. the Earl of Ellesmere.	*Coquette*—H. Thorald, Esq.	*Fair Rosamond*—The Most Hon. the Marquis of Blandford.	*Pearl*—previous to alteration) The Most Hon. the Marquis of Anglesea.	*Nautilus*—The Rt. Hon. Lord Grantham.	*Emerald*—Tender. Built for Most Hon. Marq. of Anglesea.	*Tern*—Arthur F. Gregory, Esq.	*Notice*—The Right Hon. the Earl of Desart.	*Breeze*—Captain J. Lyons.	*Lotus*—Right Hon. Viscount Clifden.	*Xarifa*—The Right Hon. the Earl of Wilton.
Length on water-line from the fore part of stem to the after part of stern-post, in feet	102.8	92.2	76.2	75.5	65.3	63.0	57.8	59.0	65.6	56.8	88.4	90.0
Breadth extreme to the outside of the plank of the bottom, in feet	27.4	22.66	21.0	19.6	19.54	19.2	18.8	15.5	16.08	15.45	21.58	21.91
Relation of length to breadth at the water-line	3.75	4.06	3.62	3.97	3.34	3.28	3.07	3.80	4.08	3.67	4.07	4.10
Draught of water, in feet and inches — Forward	10 9	9 0	10 4	7 2	6 10	6 6	6 4	6 0	6 4	6 1	8 6	9 0
Draught of water, in feet and inches — Aft	13 0	12 0	10 10	9 9	11 4	9 4	10 9	8 2	8 9	8 3	11 6	11 0
Displacement in tons (number)	434	228	185	117.6	127.5	95.0	92.7	61.7	82.9	56.2	201.3	235.4
Displacement in terms of a circumscribed parallelopipedon, contained by the length on the water-line, breadth on the water-line, and mean draught of water to the lower edge of the rabbet of the keel	.47	.40	.42	.35	.44	.435	.4	.386	.399	.409	.41	.404
Displacement before the centre of gravity, in cubic feet	7678	4026	2304	2091	2212	1680	1627	1067	1143	990	3546	4128
Displacement abaft the centre of gravity, in cubic feet	7641	3963	3160	2027	2251	1652	1619	1071	1454	977	3496	4111
Distance of the centre of gravity of displacement, from the middle of the length of the water-line, in feet	before 1.7	before .44	before 2.0	abaft .33	abaft 2.0	abaft .45	abaft 2.16	abaft .24	before .06	abaft .26	before .48	abaft .40
Distance of the centre of gravity of the solid that is before the centre of gravity of displacement, before the said centre, in feet	20.24	16.57	14.16	13.0	11.76	11.5	10.3	10.9	11.97	10.5	16.1	17.6
Distance of the centre of gravity of the solid that is abaft the centre of gravity of displacement, abaft the said centre, in feet	20.61	16.84	14.76	14.34	11.6	11.63	10.33	11.06	11.86	10.64	16.33	17.61 abaft
Distance of greatest transverse section before centre of gravity of displacement, in feet	9.16	7.5	8.4	7.5	8.25	6.33	6.4	4.0	4.5	3.0	6.5	0.1
Area of the greatest transverse section, in square feet	198.28	137.1	124.9	84.3	108.2	82.22	88.4	58.37	69.24	56.4	119.8	134.1
Area of ditto, in terms of a circumscribed rectangle contained by the breadth at the water-line, and depth from the water-line to the lower edge of the rabbet of keel	.63	.63	.62	.59	.7	.68	.65	.61	.62	.60	.61	.68
Area of the load-water section, in square feet	2398.5	1576	1371	1043.6	1003	825.3	815	658.2	791.0	643.1	1405	1584
Area of ditto, in terms of a circumscribed rectangle, contained by the length and breadth on the water-line	.86	.75	.80	.72	.78	.743	.77	.71	.75	.73	.74	.80
Area of the vertical longitudinal section, in square feet	1336	966	793	636	585	522.6	454	409	475	397	854	910
Depth of centre of gravity of displacement below the plane of load-water section, in ft.	3.8	3.38	3.1	2.79	2.89	2.56	2.51	2.12	2.35	2.10	3.0	3.23
Depth of the centre of gravity of the greatest transverse section below the plane of the load-water section, in feet	3.7	3.43	3.11	2.67	3.0	2.71	....	2.21	2.5	2.19	3.05	3.40
Distance of the centre of gravity of the load-water section from the middle of the water-line, in feet	abaft 1.4	abaft .94	abaft 1.8	abaft 1.5	before .20	abaft 1.0	abaft .1	abaft .55	abaft .56	abaft .63	abaft .90	abaft 1.60
Distance of the centre of gravity of the vertical longitudinal section abaft the centre of gravity of displacement, in feet*	3.8	2.95	3.1	1.86	1.74	1.7	2.1	1.81	1.83	1.80	2.04	1.07
Moment of stability at 10° inclination, in tons	347.2	121.7	100.0	73.9	60.3	36.01	51.5	28.21	34.2	27.96	109.6	119.8
Height of the centre of effort of the sail above the load-water line, in feet	47.05	50.05	31.35	32.51	27.77	28.99	27.4	26.56	22.65	24.3	40.5	....
Distance of the centre of effort of the sails from the centre of gravity of displacement, in feet	before 6.2	before 5.1	before 4.0	before 2.46	abaft .26	before 3.02	abaft .2	before .02	before 1.45	abaft .56	before 4.9	....
Relation of the moment of sail that is before the centre of gravity of displacement, to the moment of sail that is abaft the said centre	1.48	1.39	1.38	1.12	....	....	....	1.01	1.04	.85	1.37	....
Moment of the sails in terms of the stability	1231	1751	1577	1842	1489	2659	1560	2661	1490	1995	1987	....
Area of the sails in relation to the area of the midship section	45.4	37.8	40.2	41.7	31.5	40.1	32.7	34.4	32.6	40.6	39.1	....
Area of the sails in square feet in relation to the displacement in cubic feet	.59	.65	.77	.85	.72	.99	.89	.93	.78	1.16	.66	....

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* See Papers on Naval Architecture, vol. 1, p. 213; and the Author's Treatise on Masting Ships and Mast Making, 2nd edition, pp. 9, 10, 11.

The preceding Table contains the elements of yachts which have been distinguished by excellence in different degrees and in different respects. For, whilst fast sailing is commonly desired in the different classes of yachts, the larger vessels of this description, which are required for long voyages, are not unfrequently required to possess, first of all, the qualities of a good sea-boat. The different features of excellence may be realised with less difficulty in yachts than in ships of war; as, in the former, the disposition of the weights may be made to suit the requirements of the vessel, whilst in the latter, the design must be formed to suit the necessary and fixed distribution and quantity of the weights. Beauty of form, including moderately fine water-lines, is one of the first considerations in constructing a yacht: but the adjustments of the body must be suitably fixed, in order to excellence, and the form must be determined in harmony with a correct adjustment. Various opinions have prevailed as to the best relative position of the centre of gravity of the vessel longitudinally, and as to the centres of gravity of the fore and after bodies of the vessel. These conditions may not be correctly determined except by induction; but then, that is the sure path to excellence. The preceding table shows its use in several yachts which the author has constructed for noblemen and gentlemen; the particular condition aimed at in the alterations, which were thus made in successive constructions was, excellence in the general motions of the vessel at sea. To effect this, the relative position of the centre of gravity has been determined further forward, by increasing the fulness of the fore body forward at the lower part. The limit may not, perhaps, have been determined yet; for it appears from the descriptions given by both the owners and captains, that improvement has gone along with the successive alterations; but experience a little more extended would define it. It is in this way that the good qualities of vessels may be developed to their greatest attainable limit, and the various features of excellence be effectually combined.

The yachts to which these observations apply are the *Fair Rosamond*, the *Novice*, the *Erminia*, and the *Lotus*, in this order of succession. The report which the Marquis of Blandford gave of the performances of his yacht, led the author to suppose that her longitudinal motions would have been more satisfactory, if she had possessed a little more buoyancy forward. This idea was therefore applied afterwards in the construction of a similar schooner yacht for the Earl of Desart: the fulness at the lower part forward was increased so much as to affect the position of the centre of gravity of the displacement, to the extent which is shown in the table of elements. The *Novice* performed a voyage up the Mediterranean, being there in a heavy gale of wind; and the account given by the Earl of Desart of her behaviour and performance, satisfied the author that the alteration had been judiciously introduced into the design. The success thus gained, and the doubt whether the limit of improvement had been reached, suggested the desirableness of carrying the alteration still further. This was done in constructing the *Erminia* for the Earl of Ellesmere; and both himself and the captain of his yacht were of opinion, after a cruise up the Mediterranean, that nothing remained to be improved in her character. No proof was, however, supplied that the utmost point of excellence had been ascertained; a still further application of the principle has therefore been made in constructing the *Lotus*. In this example the alteration was made with the greatest caution, since it might be inferred that the limit was, at least, nearly reached. The conditions in which the vessels were respectively put under trial were such, that the improved performances could not be attributed to accidental causes.

The *Xarifa*, belonging to the Earl of Wilton, was constructed by Mr. Peake, of the Royal dockyard at Woolwich; and as the objects aimed at appear not to have been precisely the same as those designed by the author, she cannot be fairly compared with those. The form is adapted to a greater measure of stability, and the construction possesses a high degree of merit.

The same means of improving the ships of the Royal Navy have, at the most, rarely been resorted to. Alterations have been made, numerous enough, but they have been at once excessive, where they should have been made step by step; and numerous, where they should have been made singly. In this way, the last ship, equally with the first, of any constructor, can have been only an imperfect and uncertain experiment. In 1844, when five brigs of the same class were built from designs by different constructors, they were called "experimental brigs;" but after the trials of sailing were concluded, in which their respective merits were supposed to be exhibited, they were employed as light cruisers; and hitherto it has not been shown that any use has been made of those vessels to carry improvement in their class beyond the point which was then reached, although perfection could not be affirmed of either of them.

The elements of the *Espiègle*, *Flying Fish*, *Mutine*, *Daring*, and *Osprey* (see page 248), are in various particulars so disssimilar, as necessarily to produce different characters in those vessels. The relation of the length and breadth varies enough to make it probable that the characters of some of them would be materially dissimilar; and the extent to which difference was carried in determining other elements of the bodies respectively, confirms an inference which might be drawn at once from the different relations of the principal dimensions. While this is not the place to enter upon an investigation of the bearing of any particular features of construction in those brigs upon their respective performances at sea, it does seem the right place to suggest the thought, that half a century might realise greater improvements in naval architecture, if they were sought in the line here indicated, than we could expect in a much longer period by a less definite method of treating the subject. At the same time, it may be observed, that, by seeking to extend improvement from the point to which it had last been brought, rather than by going back to more general originality, excellence would be obtained in its most comprehensive form, at a much less cost than it can be by any unscientific succession of experiments that might be made.

APPENDIX.

Number of Line-of-Battle Ships, Frigates, Sloops, and Smaller Vessels, in Commission from the year 1793 to 1815, stating the Different Classes and the Aggregate Tonnage.

LINE OF BATTLE-SHIPS AND FRIGATES.		YEARS.													
		1793.		1794.		1795.		1800.		1805.		1810.		1815.	
Rate.	Class and Description.	No.	Tonnage.	No.	Tonnage	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
	Three-decked Ships														
1st.	120 guns.	..	..	..	..	..	..	..	..	1	2508	2	5124	..	..
,,	112 ,, 18 por.	..	..	..	..	..	..	1	2351	1	2351	1	2351	..	..
,,	112 ,, 12 ,,	..	..	..	..	..	..	..	..	1	2457	1	2457	..	..
,,	100 ,, 18 ,,	..	..	2	4572	2	4572	2	4572	..	..	..	..	..	..
,,	100 ,, 12 ,,	1	2091	3	6428	3	6428	1	2175	3	6428	1	2175	..	..
2nd.	98 ,, 18 ,,	..	..	..	..	..	..	2	4240	3	6361	..	..	1	2278
,,	98 ,, 12 ,,	4	7877	9	17356	14	2697	10	19492	8	15651	7	14367	1	2155
,,	90 ,, —	..	..	..	..	..	..	1	1814	..	..	..	..	..	..
	Two-decked Ships.														
3rd.	80 guns.	..	..	2	4188	2	4188	5	10635	4	8865	8	17919	2	4546
,,	74 ,, 24 por.	..	..	1	1901	2	3761	7	13370	8	15107	11	20971	6	11507
,,	74 ,, 18 ,,	19	31390	50	82671	50	82735	50	83597	41	70884	68	117300	37	61595
,,	64 ,, —	2	2758	18	24977	18	25013	21	29395	13	18197	11	15350	..	..
,,	60 ,, —	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4th.	56 ,, —	..	..	..	..	..	..	4	5113	1	1176	..	..	2	3258
,,	50 ,, —	7	7249	8	8314	10	10126	10	10656	11	11518	7	7599	5	6737
5th.	44 ,, —	3	2670	12	10769	9	8083	3	2702	1	908	2	1779	2	1779
	Frigates.														
,,	44 guns.	..	..	..	..	2	2759	4	5530	4	5577	2	2772	1	1388
,,	40 ,, 24 por.	..	..	..	..	1	1239	2	2536	1	1277	1	1277	6	7549
,,	40 ,, 18 ,,	..	..	..	..	..	..	2	2502	4	4067	2	2332	1	1142
,,	38 ,, —	5	4861	11	10910	20	20184	25	26074	23	24324	48	51364	45	48880
,,	36 ,, 18 ,,	6	5697	8	7119	9	8151	19	18117	20	19196	39	37372	36	33977
,,	36 ,, 12 ,,	2	1906	10	9298	9	8491	12	11165	10	9595	10	9154	1	942
,,	32 ,, 18 ,,	..	..	1	794	7	5608	6	4924	11	9475	9	7976	1	891
,,	32 ,, 12 ,,	19	13341	36	25102	62	40992	32	22773	21	14800	22	15250	4	2745
6th.	28 ,, —	10	5990	22	13126	..	..	9	5366	7	4154	7	4314	..	..
,,	24 ,, —	3	1606	4	2118	3	1605	4	2121	5	2644	4	2231	3	1934
,,	22 ,, —	..	..	..	..	..	..	4	2122	1	598	8	4277	10	5354
,,	20 ,, —	2	864	6	2663	6	2745	10	4916	6	2965	4	1922	24	11113
	Total . . .	83	87893	203	232343	229	263955	216	297742	209	261491	273	312633	188	212752

SLOOPS AND SMALLER VESSELS.		1793. No.	1793. Tonnage.	1794. No.	1794. Tonnage.	1795. No.	1795. Tonnage.	1800. No.	1800. Tonnage.	1805. No.	1805. Tonnage.	1810. No.	1810. Tonnage.	1815. No.	1815. Tonnage.
Sloops.	*Arrow* and *Dart*, mounting 28 32 por. carronades.	..	..	..	..	..	..	2	772	2	772	..	..	..	..
,,	18-gun ship-sloop.	..	..	4	1890	10	4448	32	12468	29	11538	46	19309	35	14720
,,	16 ,,	13	4591	20	6960	21	7409	21	7481	31	11230	20	9151	8	2996
,,	14 ,,	7	2118	8	2424	8	2474	8	2741	15	4358	1	305	..	..
,,	18-gun brig-sloop.	2	737	2	737	2	737	18	6243	27	9908	70	26851	67	25750
,,	16 ,,	5	1320	7	1858	10	2807	9	2490	12	3650	49	15150	21	6424
,,	14 ,,	7	1460	9	1942	8	1681	14	3307	3	744	17	4129	13	3221
,,	10 ,,	..	..	..	..	..	..	..	..	..	..	33	7842	30	7125
Bombs of 8 guns & 2 mort.		..	..	2	609	2	609	15	4917	17	6148	8	2851	7	2431
Fire-ships . . . 14 guns.		..	..	3	1273	3	1273	7	2094	1	243	..	..	..	..
Gun-brigs . . . 14 ,,		..	..	..	..	3	613	6	1175	8	1620	8	1650	2	390
,, . . . 12 ,,		..	..	..	..	13	1947	58	916	73	12835	69	12407	35	6309
,, . . . 10 ,,		..	..	..	..	1	135	4	617	2	321	1	176	1	148
Cutters, &c. . . 14 ,,		11	2160	8	1580	4	772	3	572	4	774	6	1132	7	1768
,, . . 12 ,,		6	895	6	895	5	743	9	1311	8	1237	4	600	7	1444
,, . . 10 ,,		..	..	2	208	2	198	5	569	13	1624	30	3780	13	2029
,, . . 8 ,,		..	..	2	241	2	241	3	315	1	98	1	100	1	104
,, . . 6 ,,		..	..	3	212	2	151	2	187	2	184	5	427	..	..
,, . . 4 ,,		1	95	..	..	1	47	6	400	16	1232	17	1312	4	315
Total . .		52	13379	76	20919	97	26335	222	56326	264	68522	391	107481	251	75184

Number of Line-of-Battle Ships, Frigates, Sloops, Smaller Vessels, and Steam-Vessels, in Commission, at intervals of Five Years, from 1820 to 1849 inclusive, showing their Aggregate Tonnage respectively.

LINE-OF-BATTLE-SHIPS AND FRIGATES.		YEARS.													
		1820.		1825.		1830.		1835.		1840.		1845.		1849.	
Rate.	Class and Description.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
	Three-decked Ships														
1st.	120 guns.	..	..	..	..	4	10457	3	7851	2	5235	3	7949	2	5235
,,	110 ,,	..	..	..	..	..	..	..	..	1	2457	1	3104	1	3104
,,	108 ,,	1	2289	1	2289	..	..	..	..	..	..	..	..	..	..
,,	106 ,,	1	2278	..	..	..	..	..	..	..	..	..	..	..	..
,,	104 ,,	..	..	1	2406	1	2164	1	2417	3	6859	2	4672	1	2406
	Two-decked Ships														
2nd.	92 guns.	..	..	..	..	..	..	1	2626	1	2626	1	2626	1	2613
,,	90 ,,	..	..	..	..	..	..	..	..	..	..	1	3110	..	..
,,	84 ,,	..	..	1	2285	1	2285	3	6792	4	9075	2	4512	4	9075
,,	80 ,,	1	2082	1	2082	..	..	..	..	3	6941	4	10053	2	4859
3rd.	78 ,, 24 por.	1	1927	2	3834	2	3846	1	1954	..	..	..	..	1	2056
,,	78 ,, 18 ,,	1	1907	..	..	..	..	..	..	2	4040	..	..	..	..
,,	76 ,, 24 ,,	3	5711	1	1940	1	1929	..	..	..	..	..	..	..	..
,,	76 ,, 18 ,,	..	..	..	..	2	3704	..	..	..	..	..	..	..	..
,,	74 ,,	6	10567	5	8701	4	7026	8	14049	1	1882	..	..	..	..
,,	72 ,,	..	..	..	..	..	..	..	..	8	14042	2	3511	2	3509
,,	64 ,,	..	..	..	..	1	1452	..	..	..	..	..	..	..	..
4th.	60 ,,	..	..	2	2745	..	..	..	..	..	..	..	..	..	..
,,	58 ,,	1	1199	..	..	3	4433	..	..	..	..	..	..	..	..
	Frigates.														
,,	52 guns.	..	..	..	..	6	8907	3	4500	..	..	..	..	..	..
,,	50 ,,	4	5021	2	2520	1	1720	4	6401	2	3024	7	12456	3	5541
5th.	48 ,,	1	1148	1	1160	..	..	..	..	..	..	..	..	..	..
,,	46 ,,	5	5237	5	5415	10	11073	2	2185	2	2438	..	..	..	..
,,	44 ,,	1	1029	3	3553	..	..	1	1251	1	1169	..	..	1	1221
,,	42 ,,	7	6533	7	6713	5	4710	1	946	2	2251	5	5452	1	1069
,,	40 ,,	..	..	..	..	..	..	..	..	..	..	..	..	2	3149
,,	38 ,,	..	..	..	..	..	..	1	1173	..	..	..	..	..	..
,,	36 ,,	..	..	..	..	..	..	..	..	3	4348	4	5973	2	2715
6th.	32 ,,	..	..	1	890	..	..	..	..	..	..	..	..	..	..
,,	28 ,,	..	..	5	2530	12	6233	9	4949	3	1609	..	..	..	..
,,	26 ,,	9	4026	9	4129	2	902	3	2451	15	9683	14	9975	4	3829
,,	24 ,,	5	2124	3	1277	1	428	2	1384	2	1453	2	1943	2	2130
,,	22 ,,	..	..	..	..	..	..	..	..	..	..	1	606	3	1516
	Total . . .	47	53078	50	54469	56	71269	43	60929	55	79132	49	75942	32	54027
SLOOPS AND SMALLER VESSELS.															
Sloops.	22 guns.	1	365	1	365	..	..	..	..	..	..	..	..	..	..
,,	20 ,,	11	5115	8	3795	4	1040	1	558	2	1060	..	..	..	..
,,	18 ,,	23	8895	26	10010	19	9560	14	6893	12	5650	12	5522	1	500
,,	16 ,,	..	..	..	..	2	548	8	3079	18	7385	29	9170	3	1550
,,	14 ,,	1	253	..	..	..	..	..	..	..	..	..	..	3	1399
,,	12 ,,	..	..	..	..	..	..	..	..	..	..	5	2167	8	3722
,,	10 ,,	13	3081	13	3095	18	4297	4	933	..	..	4	1199	..	..
,,	8 ,,	..	..	..	..	..	..	..	..	..	..	..	..	7	2472
,,	6 ,,	..	..	..	..	..	..	..	..	..	..	5	1797	..	..
Brigs.	16 ,,	..	..	..	..	..	..	9	3610	7	3195	..	..	..	..
,,	12 ,,	6	1099	6	1095	6	1092	..	..	..	..	..	..	1	415
,,	10 ,,	..	..	..	..	3	703	14	3356	16	3926	3	783	..	..
,,	8 ,,	..	..	..	..	..	..	..	..	..	..	..	..	2	600
,,	6 ,,	..	..	..	..	..	..	14	4376	12	3574	6	2163	6	2979
,,	4 ,,	..	..	..	..	..	..	9	2049	2	552	..	..	..	..
Brigantines, Schooners, Cutters, &c., of	14 guns.	2	501	1	238	..	..	..	..	..	..	..	..	..	..
	12 ,,	1	224	1	224	..	..	..	..	..	..	..	..	..	..
	10 ,,	6	1129	6	1091	5	763	1	319	2	284	1	161	1	161
	8 ,,	..	..	1	144	5	1096	..	..	..	..	..	..	..	..
	6 ,,	..	..	..	..	16	3943	6	1169	6	1488	5	890	4	841
	5 ,,	..	..	..	..	..	..	..	..	3	483	..	..	..	..
	4 ,,	..	..	..	..	5	587	5	648	4	765	1	108	..	..
	3 ,,	..	..	..	..	4	271	4	640	5	1128	4	1191	5	1508
Bombs		..	..	2	752	..	..	..	..	..	..	..	..	..	..
	TOTAL . . .	28	20665	65	20800	87	24840	89	27128	89	29490	66	25151	41	15366

	1830. No.	1830. Horse-Power	1830. Tons.	1835. No.	1835. Horse-Power	1835. Tons.	1840. No.	1840. Horse-Power	1840. Tons.	1845. No.	1845. Horse-Power	1845. Tons.	1849. No.	1849. Horse-Power	1849. Tons.
STEAM-VESSELS	7	880	2976	14	2186	7351	45	2834	19296	71	13340	41528	72	[illegible]	50936

Number of Line-of-Battle Ships, Frigates, Sloops, and Smaller Vessels, in Ordinary from the year 1793 to 1815 inclusive, stating the Different Classes and the Aggregate Tonnage.

LINE OF BATTLE SHIPS AND FRIGATES.		YEARS.													
		1793.		1794.		1795.		1800.		1805.		1810.		1815.	
Rate.	Class and Description.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
	Three-decked Ships														
1st.	120 guns. —	..	..	1	2747	1	2,747	..	..	..	..	..	..	3	7741
,,	112 ,, 18 por.	..	..	..	..	..	..	..	..	..	..	..	..	1	2351
,,	112 ,, 12 ,,	..	..	..	..	..	..	1	2457	..	..	..	..	1	2457
,,	100 ,, 18 ,,	2	4572	..	..	..	..	..	..	1	2286	1	2286	2	4575
,,	100 ,, 12 ,,	2	4337	..	..	..	..	2	4253	..	..	..	..	1	2175
2nd.	98 ,, 18 ,,	..	..	..	..	..	..	..	..	..	..	1	2276	1	2276
,,	98 ,, 12 ,,	11	20970	6	11491	2	3895	3	5755	3	5780	3	5774	4	8458
,,	90 ,, —	1	1814	1	1814	1	1814	..	..	..	..	..	..	..	..
	Two-decked Ships.														
3rd.	80 guns.	1	2185	..	..	2	4385	2	4538	2	4188	1	2265	4	6586
,,	74 ,, 24 por.	..	..	..	..	..	..	1	1889	2	3865	1	1927	4	7637
,,	74 ,, 18 ,,	42	69199	13	21426	11	18161	10	17140	16	26708	8	14002	41	72771
,,	64 ,, —	28	38802	11	15197	6	8262	5	6589	9	12468	1	1376	..	..
,,	60 ,, —	..	..	..	..	..	..	..	..	..	..	..	..	..	..
4th.	56 ,, —	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,,	50 ,, —	5	5280	4	4215	2	2103	..	..	1	1061	..	..	2	2372
5th.	44 ,, —	15	13488	3	2702	3	2699	1	889	1	892	..	..	..	..
	One-decked Ships.														
,,	44 gun-frigate	..	..	..	..	1	1370	..	..	..	..	..	..	..	..
,,	40 ,, 24 por.	..	..	..	..	..	..	1	1183	..	..	..	..	..	..
,,	40 ,, 18 ,,	..	..	..	..	..	..	..	..	..	..	1	1142	2	2332
,,	38 ,, —	3	2955	..	..	..	..	1	1058	5	5187	6	6625	14	14930
,,	36 ,, 18 ,,	3	2701	..	..	..	..	..	..	4	3996	1	1028	13	12380
,,	36 ,, 12 ,,	2	1852	..	..	..	..	2	1839	4	3741	1	966	..	..
,,	32 ,, 18 ,,	..	..	..	..	..	..	..	..	..	..	..	..	..	..
,,	32 ,, 12 ,,	21	14501	3	2077	2	1284	2	1482	5	3469	2	1395	..	..
6th.	28 ,, —	13	7760	2	1204	..	..	2	1222	3	1775	1	775	..	..
,,	24 ,, —	3	1553	1	519	1	519	2	1147	..	..	..	..	..	..
,,	22 ,, —	..	..	..	..	..	..	..	..	1	532	..	..	..	..
,,	20 ,, —	4	1723	1	433	2	862	3	1607	2	992	..	..	5	2337
	Total . . .	156	193716	46	63825	34	48101	38	52948	59	76950	28	41837	98	153378
SLOOPS AND SMALLER VESSELS.															
Sloops.															
,,	18-gun ship-sloop.	..	..	..	..	..	..	..	..	1	429	1	423	3	1250
,,	16 ,,	3	973	1	342	2	664	1	326	1	424	1	327	..	..
,,	14 ,,	1	306	..	..	..	..	..	..	..	..	2	674	..	..
,,	18-gun brig-sloop.	..	..	..	..	..	..	2	574	..	..	..	..	6	2307
,,	16 ,,	..	..	1	273	..	..	..	..	..	..	..	..	1	284
,,	14 ,,	2	409	1	207	1	207	..	..	..	..	..	..	..	..
,,	10 ,,	..	..	..	..	..	..	..	..	..	..	..	..	1	236
Bombs of 8 guns & 2 mort.		2	609	..	..	..	..	..	..	..	..	..	..	2	711
Fire-ships . . . 14 guns.		5	2124	..	..	..	..	1	259	..	..	..	..	..	..
Gun-brigs . . . 14 ,,		..	..	..	..	..	..	..	..	..	..	1	258	..	..
,, . . . 12 ,,		..	..	..	..	..	..	..	..	..	..	1	169	3	543
,, . . . 10 ,,		..	..	..	..	..	..	..	..	..	..	..	..	..	..
Cutters, &c. . . 14 ,,		..	..	..	..	..	..	..	..	..	..	..	..	..	..
,, . . 12 ,,		..	..	..	..	..	..	..	..	..	..	..	..	..	..
,, . . 10 ,,		..	..	..	..	..	..	..	..	..	..	..	..	..	..
,, . . 8 ,,		..	..	..	..	..	..	..	..	..	..	..	..	..	..
,, . . 6 ,,		..	..	..	..	..	..	..	..	..	..	..	..	..	..
,, . . 4 ,,		..	..	..	..	..	..	..	..	..	..	1	75	1	75
	Total . .	13	4421	3	822	3	871	4	1158	2	851	7	1926	17	5406

Number of Line-of-Battle Ships, Frigates, Sloops, Smaller Vessels, and Steam-Vessels, in Ordinary, at intervals of Five Years, from 1820 to 1849 inclusive, showing their Aggregate Tonnage respectively.

LINE-OF-BATTLE-SHIPS AND FRIGATES.		YEARS.													
		1820.		1825.		1830.		1835.		1840.		1845.		1849.	
Rate.	Class and Description.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
	Three-decked Ships														
1st.	120 guns.	5	12972	6	15588	4	10360	7	18471	9	23703	8	21187	9	23928
"	112 "	2	4805	1	2351	..	..	..	..	..	..	..	..	..	..
"	110 "	..	..	2	4574	3	7320	2	507	1	3104	1	2457	..	..
"	108 "	1	2280	..	..	1	22[illegible]6	..	..	..	..	..	..	..	..
"	106 "	..	..	2	481[illegible]	2	450[illegible]	1	2278	..	..	..	..	..	..
"	104 "	6	12758	5	11438	..	..	4	9274	4	9618	5	11805	5	12064
"	98 "	..	..	3	583[illegible]	..	..	..	..	..	..	..	..	..	..
	Two-decked Ships.														
2nd.	92 guns.	..	..	..	..	..	..	..	..	1	26[illegible]	2	5231	3	78[illegible]0
"	90 "	..	..	..	..	..	..	..	..	..	..	..	..	2	6220
"	84 "	3	6803	3	6[illegible]0[illegible]	6	13610	6	13223	7	15920	9	20483	6	13641
"	82 "	..	..	1	2139	..	..	..	..	..	..	..	..	..	..
"	80 "	5	10618	3	6[illegible]4	4	8533	2	4118	..	..	2	[illegible]180	7	1[illegible]160
3rd.	78 " 24 pdr.	4	7772	4	7696	2	3356	3	5777	2	4160	2	4118	6	12225
"	78 " 18 "	2	3500	..	..	..	..	..	..	..	..	3	62[illegible]7	..	..
"	76 " 24 "	2	3809	..	..	2	4304	1	1949	..	..	..	..	1	1917
"	76 " 18 "	3	5646	1	1889	2	3591	1	18[illegible]5	3	5[illegible]25	4	7779	..	..
"	74 "	58	101501	60	103176	46	77120	35	5965[illegible]	1	176[illegible]	2	..	..	..
"	72 "	..	..	..	..	..	..	..	..	26	455[illegible]	2[illegible]	49291	13	22956
"	70 "	..	..	..	..	..	..	..	..	..	..	2	4427	2	4427
"	64 "	..	..	2	2815	..	..	1	1439	..	..	..	..	..	..
4th.	60 "	1	14[illegible]8	..	..	..	..	..	..	..	..	..	..	..	..
"	58 "	5	6951	3	4850	..	..	1	1199	..	..	..	..	..	..
	One-decked Ships.														
"	60 guns.	..	..	5	7448	..	..	..	..	..	..	..	..	..	..
"	52 "	..	..	..	..	..	..	3	4407	..	..	..	..	..	..
"	50 "	1	1277	1	1[illegible]88	13	21707	[illegible]	13[illegible]44	15	2505[illegible]	14	23119	24	42090
5th.	48 "	5	57[illegible]1	1	117[illegible]	2	2[illegible]63	1	117	..	..	..	..	..	..
"	46 "	35	37677	3[illegible]	3778[illegible]	[illegible]	5[illegible]7[illegible]9	54	59440	2	2155	1	1[illegible]74	1	1074
"	44 "	1	10[illegible]0	..	..	1	1013	..	..	12	142[illegible]7	15	17904	4	47[illegible]9
"	42 "	25	23130	21	20116	18	174[illegible]9	4	3801	34	360[illegible]7	20	21017	20	210[illegible]
"	40 "	..	..	..	..	..	..	..	..	..	..	..	..	4	6511
"	[illegible] "	..	..	..	..	..	..	..	..	5	5077	1	946	1	946
"	36 "	..	..	1	[illegible]	..	..	1	1634	..	..	1	1634	..	..
6th.	32 "	2	1122	8	740[illegible]	1	89[illegible]	2	1662	..	..	..	..	..	..
"	30 "	..	..	2	[illegible]391	..	..	..	..	..	..	..	..	..	..
"	28 "	..	..	2	100[illegible]	2	1100	7	376[illegible]	..	..	..	..	1	923
"	26 "	2	900	4	1810	2	901	3	2394	1	[illegible]	7	5777	9	7758
"	24 "	3	1277	1	424	1	424	..	..	1	990	..	..	2	269[illegible]
"	22	..	..	..	..	..	..	..	..	..	..	2	1903	1	8[illegible]0
"	20 "	..	..	..	..	..	..	1	487	..	..	..	..	..	..
Corvette	18 "	..	..	..	..	..	..	..	..	..	..	..	..	4	28[illegible]3
	Total . .	171	25[illegible]719	178	261[illegible]64	163	237114	150	221766	1[illegible]	196950	1[illegible]7	21[illegible]218	1[illegible]5	215131
SLOOPS & SMALLER VESSELS.															
Sloops.	22 guns.	..	..	..	..	1	416	..	..	..	..	..	..	..	..
"	20 "	5	2407	2	[illegible]84	1	465	..	..	..	..	2	1060	..	..
"	18 "	41	15824	27	10470	12	4662	1	4[illegible]5	3	1407	4	1939	3	1628
"	16 "	1	29[illegible]	1	267	..	..	4	1547	3	1155	5	212[illegible]	4	2196
"	14 "	3	717	3	757	1	252	1	256	..	..	..	..	8	35[illegible]5
"	12 "	..	..	..	..	..	..	1	213	..	..	..	..	14	[illegible]
"	10 "	7	1667	24	5729	..	..	7	1645	..	..	..	..	..	..
"	8 "	..	..	..	..	..	..	..	..	..	..	..	..	2	718
"	6 "	..	..	..	..	..	..	1	235	..	..	..	..	1	[illegible]
Brigs.	16 "	..	..	..	..	..	..	2	820	..	..	..	..	..	..
"	12 "	8	1454	7	1297	3	551	2	3[illegible]0	1	[illegible]	1	445	1	445
"	10 "	..	..	4	941	12	2777	8	1850	3	705	6	1[illegible]54	..	..
"	8 "	..	..	..	..	..	..	..	..	..	..	..	..	2	716
"	6 "	..	..	..	..	..	..	1	235	2	470	2	[illegible]01	5	1374
"	4 "	..	..	1	182	..	..	1	10[illegible]	..	..	5	1141	1	228
Brigantines, Schooners, Cutters, &c., of	14 guns.	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	12 "	1	221	..	..	..	..	..	..	..	..	..	..	..	..
	10 "	1	78	1	161	..	..	4	610	1	144	..	..	..	..
	8 "	..	..	..	..	..	..	1	121	..	..	..	..	1	122
	6 "	..	..	..	..	1	235	..	..	2	352	3	[illegible]21	1	157
	5 "	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	4 "	..	..	..	..	4	91[illegible]	..	..	1	106	..	..	..	..
	3 "	..	..	..	..	..	..	1	237	..	..	1	230	..	..
Bombs		5	1737	2	701	4	1444	1	37[illegible]	..	..	..	..	..	..
	TOTAL . . .	72	24[illegible]2	72	21395	30	1177[illegible]	36	[illegible]16[illegible]	16	45[illegible]4	29	[illegible]	[illegible]	177[illegible]0

	1830.			1835.			1840.			1845.			1849.		
	No.	Horse Power	Tons.	No.	Horse Power.	Tons	No.	Horse Power	Tons.	No.	Horse Power	Tons.	No.	Horse Power	Tons
STEAM-VESSELS	3	270	829	7	1100	3646	15	2700	8204	19	5050	13675	77	20238	60370

List of Steam Vessels in course of Building in the French Arsenals, on the 31st December, 1847.

NAMES.	Class.	Power of Engines.	Laid down.		When proposed to be Launched.	Description of Propeller.	Length on the water-line.	Breadth Moulded.	Depth from the upper part of the keel to the load-water line.	Displacement in tons.	Constructors' Names.
			When.	Where.			feet.	feet.	feet.		
Le Mogador - - -	frigate - - - - -	650	1840	Rochefort	1848	paddles	232·78	40·02	16·07	2695	Hubert
L'Isly - - - - -	do. - - - - -	650	1846	Brest	1848	screw	229·65	42·65	15·91	2646	Lebas
Le Roland - - - -	corvette, 1st class -	400	1845	Toulon	1848	do.	183·73	33·46	13·45	1970	Pironneau
Le Catinat - - - -	do. do.	400	1845	Rochefort	1848	paddles	187·01	32·80	13·12	1595	Cros
Le Colbert - - - -	do. do.	320	1845	Cherbourg	1848	do.	189·30	33·46	12·86	1273	Pironneau
Le Coligny (*iron*) -	do. 2nd class -	300	1845	Rochefort	1848	do.	172·18	29·52	11·54	903	Hubert
L'Euménide (*iron*) -	do. do.	300	1846	Bordeaux	1848	do.	183·73	30·51	8·53	784	Dupuy de Lôme
Le Gorgone (*iron*) -	do. do.	300	1846	Bordeaux	1848	do.	196·85	31·16	7·54	768	Sochet
La Tisiphone - - -	do. do.	300	1847	Lorient	1848	do.	—	—	—	—	—
Le Tanger - - - -	do. do.	300	1847	Brest	1848	do.	—	—	—	—	—
Le Newton (*iron*) -	do. do.	220	1845	Cherbourg	1848	do.	177·82	29·19	7·54	861	Moissard
Le Phœnix (*iron*) -	advice-boat, 1st class	200	1846	Dunkirk	1848	do.	164·04	26·24	6·69	475	Sochet
Le Goëland (*iron*) -	do. do.	200	1846	Nantes	1848	do.	157·47	25·91	6·88	473	Dufay
Le Laborieux - - -	do. do.	200	1847	Rochefort	1848	do.	147·64	27·39	10·82	694	de Senneville
Le Prométhée (*iron*) -	do. do.	200	1847	Indret	1848	do.	—	—	—	—	—
Le Souffleur (*iron*) -	do. do.	200	1847	Indret	1848	do.	150·91	27·29	9·51	861	Gervaize
L'Ariel (*iron*) - - -	do. 2nd class	120	1847	Toulon	1848	screw	131·32	21·65	7·54	221	Dupuy de Lôme
L'Averne (*iron*) - -	do. do.	100	1847	Indret	1848	do.	—	—	—	—	—
Le Milan - - - -	advice-boat, 1st class	200	Ordered; and since laid down.	Cherbourg	—	—	—	—	—	—	—
Le Daim - - - -	do. 2nd class	120		Lorient	—	—	—	—	—	—	—
Le Flambart - - -	do. do.	100		Cherbourg	—	—	—	—	—	—	—
Le Berthollet - - -	corvette, 1st class -	400		Rochefort	—	—	—	—	—	—	—
Le Galilée - - - -	advice-boat, 2nd class	100		Lorient	—	—	—	—	—	—	—
Le Tantale - - - -	do. do.	100		Lorient	—	—	—	—	—	—	—

List of French Ships Afloat, 1*st April*, 1850.—1. *Line-of-Battle Ships & Frigates.*

NAMES	When Launched.	No. of guns.	Length on the water-line. feet.	Breadth Moulded. feet.	Depth from upper part of keel to the load-water line. feet.	Displacement in tons.	Constructors' Names.
Océan	1790	120	206·66	53·28	23·95	4982	Sané
Montebello	1812	120	207·35	53·80	24·11	5005	Sané
Souverain	1819	120					
Friedland	1840	120					
Valmy	1847	120	210·63	57·41	26·08	5154	Leroux
Hercule	1836	100	204·30	53·15	23·13	4374	Committee composed of Messrs. Sané, Rolland, Laird, Tupinier, and de Lamoriniere.
Jemmapes	1840	100					
Tage	1847	100					
Jéna (razée)	1814	90	197·08	53·28	23·45	4650	Sané
Suffren	1829	90	197·08	51·67	22·44	3998	The same Committee
Infléxible	1839	90					
Bayard	1847	90					
Diadéme	1811	86	191·93	50·03	21·98	3693	Sané
Santi-Petri	1818	86					
Neptune	1818	86					
Jupiter	1831	86					
Nestor	1810	82	181·43	47·50	20·34	2964	Sané
Marengo	1810	82					
Trident	1811	82					
Ville de Marseille	1812	82					
Alger	1815	82					
Triton	1823	82					
Couronne	1824	82					
Généreux	1831	82					
FRIGATES.							
Iphigénie	1827	60	176·90	46·34	19·02	2734	de Lamoriniere
Didon	1828	60	177·44	46·24	19·02	2470	Leroux
Indépendante	1828	60	—	—	—	—	—
Uranie	1832	60	177·44	46·24	19·35	2667	Barallier
Bellepoule	1834	60	177·12	45·92	19·16	2519	Boucher
Sémillante	1841	60					
Andromaque	1841	60					
Forte	1841	60					
Renommée	1847	60					
Persévérante	1847	60	177·12	45·92	19·68	2519	Simon
Calypso	1823	52	170·56	43·95	19·18	2265	Hubert
Syrène	1823	52					
Atalante	1825	52					
Andromède	1833	52					
Néréide	1836	52					
Cléopâtra	1838	52					
Danaé	1838	52					
Virginie	1842	52					
Poursuivante	1844	52	170·56	43·95	19·18	2269	Barallier
Alceste	1846	52	170·56	43·95	19·15	2266	Leroux
Reine-Blanche	1837	52	170·56	43·95	19·15	2266	Leroux
Pandore	1846	52	170·56	43·95	19·18	2276	Perroy
Némésis	1847	52	170·56	43·95	19·18	2276	Perroy
Gloire	1837	50	—	—	—	—	—
Erigone	1836	46	157·40	40·67	16·85	1675	Hubert
Africaine	1839	46					
Charte	1842	46					
Pénélope	1840	46	157·40	40·67	17·05	1630	Guillemard
Psyché	1844	40	157·40	42·64	17·25	1645	Boucher
Clorinde	1845	40	157·40	42·64	17·25	1645	Boucher
Pomone (auxiliary screw-ship)	1845	40	170·56	42·64	17·25	1891	Boucher
Héliopolis	1847	40	—	—	—	—	Hubert
Zénobie	1847	40	—	—	—	—	—
Sybille	1847	40	—	—	—	—	—
Jeanne-d'Arc	1847	40	—	—	—	—	—

List of French Ships Afloat, 1st April, 1850.—2. *Corvettes, Brigs, & Schooners.*

NAMES.	When Launched.	No. of guns.	Length on the water-line.	Breadth Moulded.	Depth from upper part of keel to the load-water line.	Displacement in tons.	Constructors' Names.
CORVETTES. (*Small Frigates.*)			feet.	feet.	feet.		
Héroïne	1830	32	137·76	35·09	13·87	1000	Perroy
Ariane	1830	32	137·76	35·09	13·87	1000	Leroux
Boussole	1843	32	137·76	35·09	13·87	1000	Leroux
Sabine	1834	32	137·76	35·09	13·87	1000	Leroux
Alcmène	1834	32	137·76	35·09	13·87	1000	Leroux
Embuscade	1837	32	137·76	35·09	13·87	1000	Leroux
Bayonnaise	1846	28	141·01	38·70	14·98	1100	de Moras
Artémise	1846	28	141·04	38·70	15·02	1110	Larchevesque-Thibaud
Galathée	1845	28	141·04	38·70	15·02	1096	Roger
Somme	1840	24	142·82	34·11	13·74	1359	Rolland
CORVETTES, *with Flush Deck.*							
Danaïde	1832	24	124·00	32·01	12·72	740	Campaignac
Perle	1829	18	109·22	27·70	11·77	442	—
Astrolabe	1811	18	101·20	27·71	12·39	731	Pestel
BRIGS.							
Cygne	1825	20	110.23	29·52	11·81	539	Committee as in previous page
Génie	1842	16	108·20	31·49	11·90	530	Boucher
Entreprenante ..	1846	14	111·52	31·81	12·62	482	de Senneville
Railleur	1847	—	95·12	27·55	9·84	290	Prétot
Fabert	—	—	98·42	28·20	9·77	292	Roger
ADVICE BRIGS.							
Volage	1823	10	91·17	26·24	9·15	264	Marestier
Rossignol	1842	10	90·55	27·55	9·97	286	Allix
Pandour	1843	10	90·02	27·55	9·84	293	Boucher
Alsacienne, gun-brig	1823	—	85·30	22·96	7·54	214	de Lamoriniere
SCHOONERS.							
Jouvencelle	1811	4	65·61	20·34	6·69	102	Rolland
Fauvette	1842	4	59·05	15·74	5·77	54	Boucher
Favori, cutter ..	1842	—	69·87	21·98	—	134	Allix
Fortune, transport.	1832	—	143·00	34·12	14·76	1357	Forfait

French Ships in the Course of Building, 1st April, 1850.

NAMES.	When laid down.	No. of guns.	Length on the Water line.	Breadth Moulded.	Depth from upper part of keel to the load-water-line.	Displacement in tons.	Constructors' Names.
			feet.	feet.	feet.		
Ville de Paris	1807	120	207·35	53·80	24·11	5005	Sané
Louis XIV.	1811	120	207·35	53·80	24·11	5005	Sané
Fleurus..	1825	100	204·30	53·15	23·13	4874	Committee before named.
Ulm..	1825	100					
Duguay-Trouin ..	1827	100					
Annibal..	1827	100					
Turenne	1827	100					
Henri IV.	1829	100					
Navarin	1832	100					
Austerlitz	[illegible]	100					
Wagram	1833	100					
Eylau	1833	100					
Achille	1848	90	197·08	53·28	23·45	4650	Same Committee.
Alexandre	1848	90					
Castiglione..	1835	90					
Donawerth..	1827	90					
Fontenoy	1827	90					
Hector	1834	90					
Sceptre..	1835	80					
Tilsitt	1832	80					
Duquesne	1847	80					
Tourville	1847	80					
Jean-Bart	—	80					
Vengeance..	1829	60	175·93	45·92	19·68	—	Boucher.
Entreprenante ..	1829	60					
Duchess d'Orleans	1829	60					
Semiramis..	1829	60	175·93	45·92	19·68	—	Leroux
Bellone..	1845	50	170·56	45·92	19·25	2226	de Moras
Magiciènne	1845	50	170·56	45·92	18·63	2150	Sochet
Astrée	1845	50	170·56	45·94	18·63	2210	Legrix
Hermione	1847	50	170·56	45·95	19·18	2265	Hubert
Circé	1847	50					
Flore	1847	50					
Themis..	1847	50					
Algerie	1845	40	158·26	42·64	16·02	1690	Hubert
Céres	1847	40	157·44	42·61	17·22	1730	Legrix
Amazone	1845	50	170·56	46·11	19·16	2214	Chédeville
Thisbé	1847	28	141·04	38·70	14·98	1100	de Moras
CORVETTES, *with Flush Deck.*							
Sentinelle	1846	—	111·52	28·20	12·39	410	Gervaize
Biche	1846	—	110·86	28·20	12·39	413	Dupuy de Lôme

List of Steam Vessels in the French Navy, in April 1850.

NAMES.	Class.	Power of Engines.	Launched.		Description of Propeller.	Length between Perpendiculars.	Breadth Moulded.	Depth from the upper part of the keel to the loadwater-line.	Displacement in tons.	Constructors' Names.
			When.	Where.		feet.	feet.	feet.		
Le Descartes - - - - - - -	frigate - - - - - -	540	1844	Roch fort	paddles	230·12	40·68	16·89	2978	Hubert
Le Vauban - - - - - - - -	do.	540	1845	Lorient	do.	229·46	41·01	13·58	2823	Boucher
Le Gomer - - - - - - - -	do.	450	1841	Rochefort	do.	232·78	40·02	16·07	2696	Hubert
L'Asmodée - - - - - - - -	do.	450	1841	Rochefort	do.	232·78	40·02	16·07	2696	Hubert
Le Labrador - - - - - - -	do.	450	1842	Toulon	do.	226·38	38·71	15·75	2464	Joffre
Le Magellan - - - - - - -	do.	450	1843	brest	do.	226·38	38·71	15·75	2465	Moissard
Le Montézuma - - - - - -	do.	450	1843	Rochefort	do.	226·38	38·71	15·75	2463	Hubert
L'Orénoque - - - - - - - -	do.	450	1843	Toulon	do.	226·38	38·71	15·75	2463	Pironneau
Le Cacique - - - - - - - -	do.	450	1843	Lorient	do.	226·38	40·68	16·40	2677	Legrix
Le Panama - - - - - - - -	do.	450	1843	Rochfort	do.	226·38	38·71	15·75	2466	Garnier
L'Eldorado - - - - - - - -	do.	450	1843	Lorient	do.	226·38	38·71	16·07	2558	Legrix
L'Albatros - - - - - - - -	do.	450	1844	Rochefort	do.	226·38	38·71	15·75	2466	Garnier
Le Sané - - - - - - - - -	do.	450	1847	Cherbourg	do.	232·94	40·68	16·37	2680	Campaignac
L'Infernal - - - - - - - -	corvette, 1st class	400	1843	Rochefort	do.	203·41	35·43	14·76	2004	Hubert
Le Caffarelli, (*iron*) - - - -	do. do.	400	1847	Brest	do.	209·97	35·10	15·25	1861	Chédeville
Le Prony, formerly le Socrate -	do. do.	320	1847	Brest	do.	190·29	32·81	11·97	1345	Prétôt
Le Patriote - - - - - - -	corvette, 2nd class	300	—	—	—	—	—	—	—	—
Le Caton (*iron*) - - - - - -	do. do.	300	1847	Toulon	screw	177·16	30·35	11·15	887	Dupuy de Lôme
L'Espadon - - - - - - - -	do. do.	220	1832	Indret	paddles	181·10	30·18	11·97	1178	Boucher
Le Véloce - - - - - - - -	do. do.	220	1838	Rochefort	do.	190·45	29·53	11·81	1259	Hubert
Le Lavoisier - - - - - - -	do. do.	220	1838	Indret						
Le Caméléon - - - - - - -	do. do.	220	1839	Rochefort						
Le Gassendi - - - - - - -	do. do.	220	1840	Indret						
Le Pluton - - - - - - - -	do. do.	220	1841	Brest						
L'Archimède - - - - - - -	do. do.	220	1842	Brest						
Le Phoque - - - - - - - -	do. do.	220	1842	Indret	do.	181·10	30·18	11·97	1178	Boucher
L'Élan - - - - - - - - -	do. do.	220	1843	Indret	do.	177·43	29·53	11·48	1023	Boucher
Le Caïman - - - - - - - -	do. do.	220	1843	Indret	do.	177·43	29·53	11·48	1023	Boucher
Le Titan - - - - - - - -	do. do.	220	1844	Toulon	do.	174·54	30·51	11·02	937	Boucher
Le Cassini - - - - - - - -	do. do.	220	1845	Lorient	do.	177·16	30·84	11·48	1075	Legrix

List of Steam Vessels in the French Navy, in April 1850.—*(Continued.)*

NAMES.	Class.	Power of Engines.	Launched.		Description of Propeller.	Length between Perpendiculars.	Breadth Moulded.	Depth from the upper part of the keel to the loadwater-line.	Displacement in tons.	Constructors' Names.
			When.	Where.						
						feet.	feet.	feet.		
Le Chaptal (*iron*)	corvette, 2nd class	220	1845	Paris	screw	174·87	31·17	11·15	938	Boucher
La Mouëtte (*iron*)	advice-boat, 1st class	200	1847	La Seyne	paddles	170·60	27·88	7·87	505	de Moras
Le Heron (*iron*)	do. do.	200	1847	Nantes	do.	159·45	24·93	8·00	504	Cros
Le Dauphin	do. do.	200	1847	Indret	—	150·92	24·93	9·18	492	Lavrignais
L'Éclaireur (*iron*)	do. do.	200	1846	Nantes	paddles	152·56	26·24	9·12	496	Moll
Le Petrel	do. do.	180	1846	Dunkerque	—	152·56	26·24	9·05	496	Joffre
Le Requin (*iron*)	do. do.	180	1847	Bordeaux	paddles	147·64	25·10	8·20	492	Chédeville
L'Épervier (*iron*)	do. do.	180	1847	Nantes	do.	151·25	26·24	9·84	765	Hubert
L'Ardent	do. do.	160	1830	Brest						
Le Crocodile	do. do.	160	1832	Indret						
Le Phare	do. do.	160	1833	Indret						
Le Fulton	do. do.	160	1833	Rochefort						
Le Météore	do. do.	160	1833	Rochefort						
La Chimère	do. do.	160	1833	Indret						
Le Vautour	do. do.	160	1834	Indret						
Le Styx	do. do.	160	1834	Indret						
L'Acheron	do. do.	160	1835	Rochefort						
Le Cerbere	do. do.	160	1836	Indret						
Le Tartare	do. do.	160	1836	Indret						
Le Cocyte	do. do.	160	1837	Indret						
Le Tonnerre	do. do.	160	1838	Indret						
Le Grégeois	do. do.	160	1839	Cherbourg						
Le Grondeur	do. do.	160	1839	Lorient						
L'Euphrate	do. do.	160	1839	Indret						
Le Ténare	do. do.	160	1840	Toulon						
L'Australie	do. do.	160	1844	Bordeaux	do.	160·10	26·18	9·38	679	Moissard
Le Narval	do. do.	160	1844	La Ciotat	do.	160·10	26·18	9·38	679	Moissard
Le Brandon	do. do.	160	1846	Lorient	do.	—	—	—	—	Reech
Le Solon	do. do.	160	1846	Indret	do.	157·48	25·92	9·18	555	de Lisle-Ferme
Le Castor	do. 2nd class	120	1831	Indret	do.	—	—	—	—	——

List of Steam Vessels in the French Navy, in April 1850.—*(Continued.)*

NAMES.	Class.	Power of Engines.	Launched.		Description of Propeller.	Length between Perpendiculars.	Breadth Moulded.	Depth from the upper part of the keel to the load-water line.	Displacement in tons.	Constructors' Names.
			When.	Where.						
						feet.	feet.	feet.		
Le Brasier	advice-boat, 2nd class	120	1833	Toulon	paddles	118·11	21·98	4·26	333	Vincent
Le Flambeau	do. do.	120	1837	Brest	do.	137·79	21·32	8·00	—	Sabattier
La Védette	do. do.	120	1842	Indret	do.	144·36	22·31	7·02	369	Gervaize
Le Passe-Partout	do. do.	120	1846	Indret	do.	123·26	20·80	5·64	167	Joffre
Le Pelican (*iron*)	do. do.	120	1847	Indret	screw	—	—	—	—	—
La Salamandre (*iron*)	do. do.	120	1847	Toulon	do.	—	—	—	—	—
L'Anacréon	do. do.	100	1846	Indret	paddles	131·23	20·54	4·92	192	Joffre
Le Galibi	do. do.	80	1841	Brest	do.	123·03	19·68	8·69	243	Lévesque
Le Voyageur	do. do.	80	1841	Indret	do.	134·35	19·35	5·54	243	Masson
L'Alecton	do. do.	80	1843	Cherbourg	do.	—	—	—	—	—
Le Rubis	do. do.	70	bought 1844	Toulon	do.	—	—	—	—	—
L'Antilope	do. do.	60	bought 1844	Toulon	do.	103·08	17·91	8·79	118	—
Le Chacal	do. do.	60	do.	Toulon	do.	—	—	—	—	—
Le Liamone	do. do.	60	do.	Toulon	do.	91·86	16·73	6·56	86	—
Le Basilio	do. do.	30	1843	Brest	do.	131·23	16·40	—	—	Allix
Le Serpent	do. do.	30	1843	Brest	do.	131·23	16·40	—	—	Allix
Le Guet'n'Dar	do. do.	30	—	—	—	—	—	—	—	—
STEAM-VESSELS GIVEN UP, IN 1847, FOR THE TRANSATLANTIC PACKET SERVICE.										
L'Ulloa	—	450	1842	Cherbourg	paddles	226·37	38·71	15·74	2462	Allix
Le Darien	—	450	1842	Cherbourg	do.	226·37	38·71	15·74	2465	Beauchet
Le Christophe-Colomb	—	450	1843	Brest	do.	226·37	38·71	15·74	2476	Prétôt
Le Canada	—	450	1843	Brest	do.	226·37	38·71	15·74	2474	Chédeville

List of Steam Vessels in the French Navy in 1850, *being that portion of the Steam Navy of France which was launched between the* 1*st of January*, 1848, *and the* 1*st of April*, 1850; *also, Vessels with Auxiliary Steam-power; and Steamers which were not launched on the* 1*st of April*, 1850.

NAMES.	Class.	Power of Engines.	Laid down.		Description of Propeller.	Length on the water-line.	Breadth Moulded.	Depth from the upper part of the keel to the load-water line.	Displacement in tons.	Constructors' Names.
			When.	Where.		feet.	feet.	feet.		
Le Mogador	frigate	650	1840	Rochefort	paddles	232·78	40·02	16·07	2696	Hubert
L'Isly	do.	650	1846	Brest	screw	229·65	42·65	15·91	2646	Le Bas
Le Colbert	corvette, 1st class	320	1845	Cherbourg	paddles	189·30	33·46	12·86	1274	Pironneau
L'Euménide (*iron*)	do. 2nd class	300	1846	Bordeaux	do.	183·73	30·51	8·53	784	Dupuy de Lôme
Le Gorgone (*iron*)	do. do.	300	1846	Bordeaux	do.	196·85	31·16	7·54	768	Sochet
Le Tanger	do. do.	300	1847	Brest	do.	—	—	—	—	——
Le Newton (*iron*)	do. do.	220	1845	Cherbourg	do.	177·82	29·19	7·54	—	Moissard
Le Phœnix (*iron*)	advice-boat, 1st class	200	1846	Dunkirk	do.	164·04	26·24	6·69	475	Sochet
Le Goëland (*iron*)	do. do.	200	1846	Nantes	do.	157·47	25·91	6·88	473	Sanial Dufay
Le Laborieux	do. do.	200	1847	Rochefort	do.	147·64	27·39	10·82	694	de Senneville
Le Prométhée (*iron*)	do. do.	200	1847	Indret	do.	—	—	—	—	——
Le Souffleur (*iron*)	do. do.	200	1847	Indret	do.	150·91	27·29	9·51	861	Gervaize
Le Milan	do. do.	200	1848	Cherbourg	do.	—	—	—	—	——
L'Ariel (*iron*)	do. 2nd class	120	1847	Toulon	screw	131·32	21·65	7·54	222	Dupuy de Lôme
Le Daim	do. do.	120	1848	Industrie	paddles	—	—	—	—	——
Le Flambart	do. do.	120	1848	Industrie	do.	—	—	—	—	——
L'Averne (*iron*)	do. do.	100	1847	Indret	screw	—	—	—	—	——
La Pomone	frigate	auxiliary 220	—	Lorient	do.	170·56	42·64	17·25	1891	Boucher
La Biche	corvette	auxiliary 120	1846	Dunkirk	do.	110·86	28·20	12·39	413	Dupuy de Lôme
La Sentinelle	do.	auxiliary 120	1846	Bordeaux	do.	111·52	28·20	12·39	440	Gervaize
Le Pingouin	do.	auxiliary 30	—	Bordeaux	do.	108·26	18·04	6·23	125	Chaigneau
Le Napoléon	line-of-battle	900	1847	Toulon	do.	233·92	53·21	23·46	4973	Dupuy de Lôme
Le Berthollet	corvette, 1st class	400	1849	Rochefort	—	—	—	—	—	——
Le Catinat	do. do.	400	1845	Rochefort	paddles	187·01	32·80	13·12	1595	Cros
Le Roland	do. do.	400	1845	Toulon	screw	183·73	33·46	13·45	1970	Pironneau
Le Coligny (*iron*)	do. 2nd class	300	1845	Rochefort	paddles	172·18	29·52	11·54	903	Hubert
La Tisiphone	do. do.	300	1847	Lorient	do.	—	—	—	—	——
Le Tantale	advice-boat, 2nd class	100	1849	Industrie	—	—	—	—	—	——
Le Galilée	do. do.	100	1849	Industrie	—	—	—	—	—	——

An Abstract of the State of the French Navy, in the years 1842, 1845, 1847, *and* 1850.

DESCRIPTION.	JANUARY, 1842.							APRIL, 1845.							JANUARY, 1847.							APRIL, 1850.†						
	In Commission.							In Commission.							In Commission.							In Commission.						
Sailing Ships and Vessels.	As Cruisers, or in active service.	In port, &c.	Under Repair.	Fitting out.	Laid up.	Building.	Total.	As Cruisers, or in active service.	In port, &c.	Under Repair.	Fitting out.	Laid up.	Building.	Total.	As Cruisers, or in active service.	In port, &c.	Under Repair.	Fitting out.	Laid up.	Building.	Total.	As Cruisers, or in active service.	In port, &c.	Under Repair.	Fitting out.	Laid up.	Building.	Total.
Ships of 120 guns........	4	..	..	..	..	3	7	1	3	..	..	..	3	7	2	2	..	..	..	3	7	2	2	..	1	..	2	7
Ships of 100 ,, ...	2	..	..	..	..	11	13	1	1	..	..	..	11	13	..	1	..	..	1	11	13	2	..	..	..	2	9	13
Ships of 90 ,, ...	3	..	..	..	..	9	12	1	1	1	..	..	9	12	2	1	..	..	..	9	12	2	2	..	..	..	7	11
Ships of 86 ,, ...	4	..	..	..	1	..	5	2	..	..	..	3	..	5	1	1	..	..	..	..	2	1	1	..	..	..	..	2
Ships of 82 ,, ...	..	..	..	..	..	..	..	2*	1	1	..	1	..	5	..	..	..	..	2	..	2	..	1	..	..	2	..	3
Ships of 80 ,, ...	7	..	..	..	2	..	9	1	3	..	..	..	..	4	1	3	..	..	4	1	9	..	4	..	..	3	5	12
Frigates of 60 guns......	2	1	..	..	7	6	16	3	3	..	..	2	6	14	2	2	..	..	4	7	15	1	2	..	..	8	5	16
Frigates of 58 ,, ...	1	..	..	..	..	..	1	1	..	..	..	..	..	1	..	1	..	..	..	..	1	..	..	..	1	..	..	1
Frigates of 52 ,, ...	5	..	..	..	2	..	7	2	2	..	..	2	..	6	3	1	..	..	1	..	5	3	2	..	..	4	..	9
Frigates of 50 ,, ...	3	..	..	..	1	7	11	2	4	..	..	..	5	11	4	2	..	..	..	9	15	1	2	..	..	3	13	19
Frigates of 46 ,, ...	4	..	..	..	2	..	6	2	1	..	..	1	..	4	2	1	..	..	1	..	4	..	2	..	..	1	..	3
Frigates of 40 ,, ...	1	..	..	..	1	3	5	2	1	..	..	1	5	9	2	2	..	..	2	10	16	5	1	..	..	2	..	8
Corvettes of 30 guns	7	..	..	..	3	..	10	6	1	..	..	..	3	10	6	..	..	..	2	6	14	8	..	..	..	4	4	16
Corvettes of 28 ,, ...	2	..	..	..	1	..	3	..	1	..	..	1	..	2	..	1	..	..	1	..	2	..	1	..	..	..	..	1
Corvettes of 26 ,, ...	..	..	..	..	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Corvettes of 24 ,, ...	8	..	..	..	..	..	8	5	1	..	..	1	..	7	4	1	..	..	1	2	8	2	..	..	..	2	..	4
Corvettes of 20 ,, ...	3	..	..	..	1	..	4	1	..	..	..	2	..	3	2	..	..	..	1	..	3	..	..	..	..	3	..	3
Advice-Corvettes, 16 and 14 guns..................	2	..	..	..	4	..	6	1	..	..	..	2	..	3	1	..	..	..	1	..	2	6	1	..	..	4	..	11
Brigs of 20 guns........	15	..	..	..	6	4	25	13	2	..	..	6	2	23	10	2	..	..	6	4	22	4	..	4	..	11	3	22
Brigs of 18 ,, ...	..	..	..	..	1	2	3	1	..	..	..	2	..	3	3	..	..	..	2	..	5	1	..	..	..	2	..	3
Brigs of 16 and 14 guns.	2	..	..	..	2	..	4	..	..	..	..	..	..	..	..	..	..	..	1	..	1	1	..	..	..	..	..	1
Advice-Brigs of 10 guns .	16	..	..	..	3	4	23	9	4	..	..	8	..	21	16	..	..	..	5	..	21	3	1	..	..	15	..	19
Gun-Brigs of 8 guns	..	..	..	..	..	..	..	..	..	..	..	2	..	2	..	..	..	..	1	..	1	..	1	..	..	..	..	1
Gun-Brigs of 6 ,, ...	..	..	..	..	..	..	..	1	..	..	..	..	..	1	..	..	..	..	..	..	..	1	..	..	..	..	..	1
Gun-Brigs of 4 ,, ...	7	..	..	..	1	..	8	5	..	..	..	2	..	7	5	1	..	..	3	..	9	1	..	..	..	1	..	2
Schooners, Cutters, Luggers, &c., - 6 to 8 guns	13	..	..	..	2	..	15	13	..	..	..	2	1	16	14	..	..	..	3	..	17	8	..	..	..	9	..	17
Bâtiments de flotille, consisting of Cutters, Schooners, &c., of 4 guns and under........	43	..	..	..	11	..	54	23	1	..	..	7	..	31	22	3	..	..	3	..	28	16	1	..	..	17	..	34
Corvettes de Charge of 800 tons..................	15	..	..	..	1	2	18	11	..	1	..	1	..	13	6	5	..	..	1	..	12	1	..	..	..	2	..	3
Transports, &c., of 925 tons and under	19	..	..	..	15	..	34	21	1	..	..	13	9	44	13	2	..	..	9	6	30	17	9	..	..	8	..	34
Total Sailing Ships and Vessels	188	1	..	..	67	51	307	131	31	2	..	59	54	278	121	32	..	..	55	68	276	86	33	4	2	103	48	276
Steam Ships and Vessels.																												
Steam-frigates of 650 h.p.	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	2	2	..	1	..	..	1	..	2
Steam-frigates of 540 ,,	..	..	..	..	..	2	2	1	1	..	..	..	..	2	..	1	..	..	1	..	2	1	1	..	..	..	..	2
Steam-frigates of 450 ,,	..	..	..	3	1	1	5	2	1	..	..	..	2	5	5	8	..	..	2	2	17	6	7	..	1	2	..	16
Steam-corvettes of 400 ,,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	2	3	..	1	..	..	..	3	4
Steam-corvettes of 320 ,,	..	..	..	..	1	..	1	1	..	..	..	..	5	6	1	..	..	..	..	2	3	1	1	..	..	..	..	2
Steam-corvettes of 300 ,,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	4	..	2	..	..	2	2	6
Steam-corvettes of 260 ,,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	1	1	..	..	..	..	..	1
Steam-corvettes of 220 ,,	5	..	..	..	..	4	9	7	..	..	..	..	4	11	9	4	..	..	..	1	14	11	3	1	..	1	..	16
Steam-vessels of 200 ,,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	4	2	3	..	..	2	..	7
Steam-vessels of 180 ,,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	4	4	2	2	..	..	..	..	4
Steam-vessels of 160 ,,	21	..	..	..	1	..	22	18	..	..	5	..	2	25	17	5	..	1	..	..	23	13	4	..	..	4	..	21
Steam-vessels of 150 ,,	1	..	..	..	..	..	1	1	..	..	..	..	..	1	2	..	..	..	..	..	2	..	..	..	..	..	..	..
Steam-vessels of 120 ,,	1	..	..	..	..	..	1	2	..	..	..	..	..	2	..	2	..	..	2	4	8	6	1	..	..	3	..	10
Steam-vessels of 100 ,,	1	..	..	..	..	..	1	1	..	..	..	..	..	1	..	..	..	1	..	..	1	2	..	..	..	..	2	4
Steam-vessels of 80 ,,	2	..	..	..	1	..	3	3	..	..	..	..	..	3	1	2	..	..	..	..	3	1	1	1	..	..	..	3
Steam-vessels of 70 ,,	..	..	..	..	..	..	..	1	..	..	..	..	..	1	..	..	1	..	..	..	1	1	..	..	..	..	..	1
Steam-vessels of 60 ,,	2	..	..	1	..	..	3	6	..	..	..	..	1	7	3	2	..	..	..	1	6	1	2	..	..	..	..	3
Steam-vessels of 50 ,,	..	..	..	..	..	..	..	2	..	..	..	..	..	2	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Steam-vess. of 30 & 20 ,,	..	..	..	..	..	..	..	2	..	..	..	..	..	2	2	1	..	..	..	..	3	..	3	..	..	..	..	3
Total Steam-ships and vessels	33	..	..	4	4	7	48	47	2	..	5	..	14	68	40	25	1	2	6	27	101	48	32	2	1	15	7	105

* 82-gun ships were formerly 80-gun ships.

† There were also a frigate, two corvettes, and an *aviso*, with auxiliary steam-power, all in commission.

Elements of Construction of Ships in the Russian Navy, in 1836.

NAMES.	No. of Guns.	Length.	Depth.	Breadth.	Area of the Midship Section.	Area of the Load-water Section.	Displacement in tons.	Centre of gravity of displacement before the middle of the length of load-water line.	Centre of gravity of displacement below the plane of the load-water section.	Distance of the midship section before the middle of the length of load-water line.	Distance between the centre of gravity of displacement and the meta-centre.
		feet.	feet.	feet.	sq. feet.	sq. feet.		feet.	feet.	feet.	feet.
Warsaw - - - - - -	120	205·89	55·64	22·26	1100·9	10261·0	4857·1	3·43	9·19	17·16	14·18
Brave - - - - - - -	120	201·6	52·4	21·6	962·3	9478·0	4184·4	2·04	8·78	10·36	13·37
Emperor Alexander -	110	197·16	53·08	21·33	974·7	10303·9	4244·6	2·97	8·30	16·05	13·2
Empress Catherine -	84	191·93	52·21	21·18	890·6	8695·4	3516·6	3·18	8·21	14·59	13·93
Empress Mary - - -	84	196·0	51·8	20·63	865·3	8965·8	3575·5	2·6	8·47	12·35	14·17
Ezekiel - - - - - -	80	176·7	49·33	19·40	792·8	7530·5	2918·7	3·12	7·36	14·64	11·66
Smolanck - - - - -	74	177·12	49·6	20·0	804·9	7536·4	2876·7	2·57	7·81	11·30	12·92
Vienna - - - - - -	60	170·86	43·82	17·52	580·9	6161·2	1883·7	4·64	6·23	17·71	12·33
Penelope - - - - -	46	152·67	39·92	16·65	505·6	5088·5	1452·5	3·82	6·11	15·03	10·69
Mary - - - - - - -	44	160·00	42·10	16·66	527·3	5693·2	1664·6	2·27	6·26	9·63	12·47
Swift - - - - - - -	44	153·70	40·30	16·50	478·7	5095·7	1419·1	3·20	5·75	13·04	11·19
Favourite - - - - -	20	106·40	30·00	11·25	223·2	2695·3	488·5	1·05	3·94	4·84	9·53
Mercury - - - - - -	20	94·00	30·70	12·30	257·7	2257·7	428·1	0·55	4·14	1·99	9·20

Elements of Construction of Ships now in the Danish Navy.

NAMES.	No. of Guns.	Length.	Breadth.	Depth.	Displacement in cubic feet.	Area of the Midship Section.	Area of the Load-water Section.	Centre of gravity of displacement before the middle of the length of load-water line.	Centre of gravity of displacement below the plane of the load-water section.	Distance of the midship section before the middle of the length of load-water line.	Meta-centre above the centre of gravity of displacement.
		feet.	feet.	feet.		sq. feet.	sq. feet.	feet.	feet.	feet.	feet.
Gefion - - - -	48	164·8	42·23	17·20	59168	509·7	5801·3	3·15	6·03	6·53	12·10
Thetis - - - -	46	154·5	39·65	15·87	49344	453·0	5181·2	3·04	5·68	6·20	11·71
Freia - - - - -	46	152·4	38·93	15·65	46619	428·2	4934·3	3·49	5·67	5·95	11·05
Valkyrien - -	24	123·6	32·44	12·97	22907	292·0	3328·4	2·68	4·35	4·81	10·68
Diana - - - -	20	115·3	30·18	11·95	18767	238·7	2853·5	2·23	4·13	4·59	9·39
Lille Belt - -	18	111·2	29·87	10·82	15942	227·9	2586·4	2·03	3·77	4·16	9·41
St. Thomas - -	16	98·8	27·66	11·35	13385	199·9	2216·4	2·36	3·84	4·15	8·78
Allart - - - -	12	92·7	26·05	10·52	10472	170·6	1974·7	2·46	3·45	3·85	8·87
St. Proix - - -	—	89·6	24·72	10·00	9214	155·6	1765·9	2·35	3·37	3·65	7·86
Maiaria - - - -	—	80·1	23·58	8·67	6534	131·3	1404·5	0·185	2·98	3·20	7·51
Atthalante - -	—	72·1	20·60	6·35	5009	94·5	1266·7	0·670	2·35	2·61	7·42
Philen - - - -	—	55·6	15·45	4·37	1421	40·5	628·5	0·896	1·48	1·63	6·68

Elements of Swedish Ships constructed by Chapman.

No. of Guns.	Length.	Breadth.	Depth.	Displacement.	Area of the Midship Section.	Area of the Load-water Section.	Centre of gravity of displacement before the middle of the length of load-water line.	Distance of the midship section before the middle of the load-water line.	Centre of gravity of displacement below the plane of the load-water section.	Distance between the centre of gravity of displacement and the meta-centre.
	feet.	feet.	feet.	cubic feet.	sq. feet.	sq. feet.	feet.	feet.	feet.	feet.
110	203·64	54·68	21·30	140797	964·16	9673·98	3·16	14·67	8·34	14·77
94	192·94	51·87	20·41	118161	857·92	8641·14	2·99	13·77	7·88	14·10
80	182·63	49·54	19·47	98915	762·47	7775·26	2·84	12·93	7·38	13·69
74	174·55	48·16	18·93	88804	709·87	7291·95	2·74	12·41	7·10	13·45
66	172·18	47·15	18·51	81712	671·78	6940·99	2·67	12·04	6·89	13·28
44	159·94	41·58	16·36	53208	486·81	5563·99	2·36	10·09	5·78	12·54
40	149·35	39·36	15·27	43173	424·28	4885·14	2·22	9·50	5·36	12·11
36	138·74	37·11	14·18	34476	365·91	4246·21	1·73	8·91	4·94	11·85
32	129·68	35·14	13·25	28029	319·36	3733·67	1·61	8·39	4·58	11·25
28	122·85	33·64	12·54	23741	286·35	3367·94	1·52	8·01	4·31	10·94
24	117·94	32·55	12·03	20955	263·83	3116·12	1·46	7·74	4·12	10·71
20	113·35	31·53	11·56	18569	243·59	2890·40	1·41	7·49	3·90	10·49
16	103·23	29·23	10·51	13923	201·65	2417·78	1·28	6·92	3·55	10·00
14	94·49	27·21	9·61	10591	168·46	2041·27	1·17	6·45	3·21	9·55
12	86·29	25·27	8·75	7988	140·07	1715·66	1·07	5·98	2·89	9·12
10	75·83	22·74	7·67	5356	107·60	1339·34	0·94	5·40	2·50	8·53
8	66·29	20·37	6·68	3521	81·68	1034·54	0·82	4·89	2·15	7·97

Elements of Construction of Ships now in the Swedish Navy.

No. of Guns.	Length.	Breadth.	Draught of Water.		Displacement.	Area of Midship Section.	Area of Load-water Section.	Centre of gravity of displacement before the middle of the load-water line.	Centre of gravity of displacement below the plane of the load-water section.	Height of the meta-centre above the water line.	Area of Sails.	Moment of Sails.	Centre of effort of the sails before the centre of gravity of the ship.
			Forward.	Aft.									
	feet.	feet.	feet.	feet.	tons.	sq. feet.	sq. feet.	feet.	feet.	feet.	sq. feet.	feet.	feet.
76	184·58	49·83	20·67	22·33	2846·3	760·9	7875·7	2·11	7·31	6·52	30629	2668010	8·68
52	177·0	45·90	20·40	22·0	2291·4	640·3	6475·6	2·42	6·94	5·50	27281	2150805	14·61
40	152·42	40·10	16·66	18·16	1328·2	475·0	5145·6	2·66	5·66	6·4	19486	1297879	3·97
18 (Corvette)	113·0	30·92	12·79	14·33	530·4	247·6	2795·0	2·43	4·11	5·46	11782	603858	3·99
10 (Brig)	98·88	29·13	11·41	12·83	360·6	192·4	2218·0	2·47	3·61	—	10480	483230	2·25

An Abstract of the Number of British Ships of each Class, built from the Accession of Geo. 1st to 1850; with the principal dimensions of the largest Ship of each Class in the respective Reigns.

Built during the Reign of	No. of Guns.	No. of Ships.	Principal Dimensions of the largest Ship. Length on Deck. ft.	ins.	Breadth Extreme. ft.	ins.	Burthen in Tons.
George the First	90	1	163	0	47	3	1565
	84	1	175	4	50	3¼	1918
	80	2	164	0	47	6	1586
	70	2	151	0	41	10	1147
	60	1	144	7	39	0	954
	50	3	134	6	36	3	767
	44	2	134	0	36	0	756
	8	3	76	6	22	4	164
	6	1	51	6	15	2¼	46
	4	1	72	0	20	2	122
	2	1	54	2	17	1	65
George the Second	100	2	178	0	51	9¼	2047
	90	7	174	11¼	48	7¼	1814
	80	5	166	0	47	0	1615
	74	12	171	2¾	49	4	1799
	70	13	161	0	46	1	1478
	68	1	164	0	47	2	1567
	66	1	158	0	45	5	1401
	64	7	160	0	45	4	1436
	60	17	154	8	43	10	1297
	50	5	143	3	41	3	1044
	44	4	140	9	37	1¾	856
	36	3	128	4	35	10¾	728
	32	11	125	5¼	35	9	704
	28	12	125	2¼	35	9¼	706
	24	8	113	3	32	3¾	522
	22	2	107	8½	30	5	440
	20	7	109	4	30	6	451
	16	2	96	4	27	4	313
	14	1	91	6	26	1¾	272
	12	1	72	0	22	6	157
	10	8	88	8	24	3	238
	8	7	73	6	21	0	144
George the Third	120	2	205	0	54	6	2616
	112	1	198	0	52	7	—
	110	1	190	0	52	6	2289
	104	3	196	0	53	0	2278
	100	5	190	2¼	53	2¼	2351
	98	18	185	0	51	2	2121
	90	1	176	1½	49	0¾	1833
	80	2	183	8	50	8	2062
	78	1	181	1	49	1¾	1919
	76	3	182	0	49	3	1940
	74	118	184	2¼	50	0½	1964
	70	1	162	0	44	8	1426
	64	45	173	1	43	4	1439
	56	2	175	1½	43	1¾	1426
	52	1	146	0	40	8	1052
	50	20	166	4¼	42	9¼	1388
	48	1	158	0	40	8	1172
	46	14	154	3	39	8½	1098
	44	22	140	3¼	38	6¼	911
	42	20	152	5¼	38	0	996
	40	4	159	3¾	42	7¾	1277
	38	20	150	0	39	10½	1058
	36	21	150	2	39	9	1053
	32	57	144	0	37	8½	919
	28	34	127	4	34	10	689
	26	19	113	3¼	29	8¼	484
	24	13	119	0	32	9	563

An Abstract of the Number of British Ships of each Class, &c.—(Continued.)

Built during the Reign of	No. of Guns.	No. of Ships.	Principal Dimensions of the largest Ship.				Burthen in Tons.
			Length on Deck.		Breadth Extreme.		
			ft.	ins.	ft.	ins.	
George the Third .	22	12	118	2	32	0½	540
	20	7	108	0	30	3	435
	18	61	100	3	30	8	387
	16	16	108	10	29	7	422
	14	92	108	4	29	7	429
	12	14	96	4	25	11	285
	10	20	90	7	24	8	248
	6	2	90	3	24	6½	237
George the Fourth .	120	5	205	0	53	8½	2619
	110	2	197	11	53	0	2446
	106	1	196	0	52	8½	2404
	104	1	186	0¾	51	4½	2149
	84	10	193	10	51	5½	2255
	82	1	187	2	50	11½	2139
	80	6	196	6	51	7	2299
	74	36	176	5	47	11	1774
	60	3	174	0	45	1½	1572
	58	1	154	4	42	0½	1199
	52	6	172	9	43	8¾	1468
	50	3	159	2½	42	4	1260
	46	58	159	0	41	5½	1251
	42	21	145	0	38	2	959
	32	1	118	5	31	7	522
	28	14	119	0	33	8	606
	26	12	121	6½	34	1	620
	20	17	118	9	33	3½	558
	18	22	109	8	30	7	435
	10	32	90	9	24	9½	256
	6	17	89	10	24	8½	237
	steam vessels	22	179	4½	31	11	835
William the Fourth .	120	3	205	6	54	9	2718
	92	1	205	6	53	10½	2626
	84	3	196	6	51	7	2299
	80	1	190	0	56	3	2609
	50	1	176	0	52	0½	2082
	46	1	159	0	41	8	1228
	36	3	160	0	48	5½	1633
	28	2	130	0	35	2¾	717
	26	6	130	0	40	5¾	925
	18	7	120	0	37	4	734
	16	1	105	0	33	2	485
	12	9	102	5	32	0	435
	10	5	90	0	29	2¼	323
	6	4	95	1½	30	1¼	363
	brigantines	10	95	2½	30	1	361
	steam vessels	23	178	0	37	0½	1111
Victoria to 1850 .	120	2	205	6	54	9½	2721
	110	1	204	2½	59	2½	3104
	92	2	205	6	53	9½	2622
	90	1	204	0	59	4½	3110
	80	8	190	0	56	1½	2596
	78	1	188	8	50	5	2098
	70	2	180	0	53	6	2214
	50	9	180	0	52	2	2126
	36	5	160	0	48	5½	1634
	26	8	131	2	40	3	923
	20	1	120	1	37	3½	734
	18	3	120	0	37	4	734
	16	15	110	0	34	6	549
	12	9	103	1	32	0½	445
	10	3	93	0	29	3	329
	6	5	95	0	30	0	358
	3	1	90	0	29	0	319
	steam vessels	92	226	2	42	0	1850

9 AU 51

RECORD OF TREATMENT, EXTRACTION, REPAIR, etc.

Pressmark: 8805 e 28 .

Binding Ref No: 300933/4 .

Microfilm No:

Date	Particulars
17. 6. 1998.	Chemical Treatment
	Fumigation
	Deacidification MAG-BI-CARB.
	Lamination 8·5gsm TISSUE (14 LVS) . JAPANESE TISSUE REPAIR.
	Solvents
	Leather Treatment Book Refurbished Wash Saddle Soap, Pottasium Citrate Starch Paste, British Museum, Leather Dressing, Spirit Dye
	Adhesives WHEAT STARCH PASTE. ANIMAL GLUE.
	Remarks

PRESERVATION SERVICE

SHELFMARK 8805.E.28.

THIS BOOK HAS BEEN
MICROFILMED (1998)
N.S.T.C.
MICROFILM NO SEE RPM

DERRY & SONS
NOTTINGHAM 1998